STATUS OF GIS EDUCATION AT 4-YEAR COLLEGES AND UNIVERSITIES IN THE UNITED STATES

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CHAPTER I

INTRODUCTION

A. GENERAL INTRODUCTION

Overview

> *"The aim of education is to transfer information from the lecturer towards the student. Application and creative use of this information will be the result if the translation is successful. GIS is not different compared with other educational fields" (Linden, 1990 p.33) "but different objectives should be distinguished according to a possible definition and use of a GIS" (Baker 1991 p. 1348).*

Over the past 15 years, the development, acquisition, and implementation of Geographic Information Systems (GIS) has increased, and GIS has become a large industry in the United States, being utilized by the private sector, the public sector, and in academia.

GIS allows flexible and efficient storage and display of spatially referenced data and exchange of spatial data. Recently the term Geographic Information Systems emerged as representing an arm of the geosciences, which are related with the Earth, such as geography, geology, meteorology, geophysics, geochemistry, and hydrology. Today, many universities and community colleges offer at least one GIS

course, certificate program, certification, or degree in Geographic Information Systems. The declining relative cost of computer software and hardware, the increasing ease-of-use of the technology, and its increasing power have contributed to a rapid increase in the number of GIS applications.

Education in the area of GIS is a complicated proposition because GIS topics may be addressed throughout a broad range of academic programs, and the knowledge of technology is available from a broad assortment of educational sources that include universities, community colleges, and private vendors. Likewise, the application of GIS is also available to a broad range of fields, like geography, geology, forestry, engineering, and agronomy.

Fast and continued growth in the use of GIS in private industry, government, and the academic arena has raised the interest in educational opportunities now available to GIS practitioners. Since the use of GIS has been growing rapidly, many practitioners seek basic and advanced education and training. For this reason, numerous vocational schools, community colleges, four-year colleges, and universities are adopting some GIS courses. However, increasing the capacity of these educational programs alone has not solved the problem of new demands on GIS education.

B. THE PROBLEM

Statement of the Problem

GIS education started in the 1970s and increased dramatically in the 1990s when many four-year universities and community colleges started to offer courses related to GIS. Little empirical research had been done on GIS education by the middle of the 1990s in order to demonstrate its benefits to individual practitioners, continuing education institutions, and professional organizations. The few studies that were done did not seem to result in improvements in the standards in GIS education.

Because GIS is a relatively new, very broad, and very popular subject, it has great potential for individuals, academics, and the business world. Because it is very broad, the tremendous effort and research since the 1990s has not been enough to identify clearly what GIS education is about. In most cases, educational institutions developed and offered GIS programs in order to provide GIS experts to the public. However, there has been no study showing the relationships among local businesses, the local population, government, and academic units in GIS. Whether a direct relationship exists between local population and those

institutions offering GIS is unknown. Who creates the demand for GIS experts (local government, business)? What types of relationships exist between the spatial distribution of GIS education institutions and the type of GIS education? On the other hand, how do local businesses, the population of the region, and government agencies affect the size and type of GIS education available in the area? In addition, how does the size of the academic institution affect the level of GIS education in the institution?

Purpose

The purpose of this study is as follows:

1. To identify the current status of GIS education, including certificate programs, certification programs, and degree programs offered in the geography departments of universities in the US. One of the main objectives is to present who/what/how GIS education is provided. The research will include only geography departments since most of the GIS programs are in the Geography Department.
2. To provide information on the status of curricula for Geographic Information Systems in order to see what types of courses are offered from different academic departments.

3. To develop a method for identifying the relationship between GIS education, the institution, and the market. This research will seek to discover the relationship between the community and the programs and whether the program serves local or nationwide needs.
4. To analyze and determine GIS, business and community relationships, and the spatial distribution of GIS programs.

Importance of the Study

This study contributes findings that benefit individuals, academic institutions, and the business world. It maps the current status of GIS education from a different perspective. Identifying the current status of GIS programs will help educators to understand the future pattern of GIS programs locally and nationwide. Knowing the current status of GIS institutions and their characteristics will help individual practitioners and companies to discover what GIS education offers them and what other services could be provided.

Since the research includes the relationship between GIS education institutions and the community around them, the findings enable academicians to see the expectations of businesses and individuals. Therefore, the public and

business worlds will recognize what is out there in GIS education. By knowing the status and distribution of GIS certificate, certification, and degree programs in the nation, academicians and administrators can better justify where the demand is. If the demand for GIS comes mostly from agricultural applications, an institution's efforts to educate individuals should focus on this area. On the other hand, if the governmental and private sectors are searching for experts in GIS, then institutions should focus on these areas. In addition, the study shows whether the service area of a GIS institution is regional or national. By better understanding the destination of students after finishing the program, administrators will be able to serve the needs of the public and the students around the institution. Policy makers will better understand the nature of GIS education and the demand. The pattern of mobility of the GIS graduates will give a greater understanding of the effectiveness of the institutions in serving the higher education needs and desires of the public.

This study also provides researchers and administrators insights into the relationship between the type of university (Research I-II, undergraduate vs. graduate programs, etc.) and GIS education. It will reveal the

focus of the programs in public and private universities along with those in research and service universities. Moreover, the study provides administrative insights into the manner in which the programs can be easily adapted or converted according to demand in the area around the program. Furthermore, the study includes curricula that GIS institutions use. The types of the courses related to GIS and other supportive subject areas (computer, programming, data base management, etc.) can be identified. The findings will help administrators of institutions who are trying to develop a new GIS program or to modify an existing one.

The study analyzes the demographic changes around an institution offering GIS programs. In addition, the study provides a unique spatial analysis of current GIS institutions, including documentation and literature related to GIS education for researchers and academicians in the United States.

Delimitations

1. The study included GIS programs only in four (4) year colleges and universities in the United States.
2. The study includes only geography departments in universities in the Association of American Geographers (AAG) Directory 2000. GIS programs under

different majors and other than those listed in the AAG Directory 2000 were not included. Since geography departments have GIS programs, the samples are reliable because the samples cover the most distinguished higher education institutions and most of the geography departments in the nation. Some professional organizations and GIS vendors may provide GIS education. However, the number is small compared to the number of academic institutions.

3. The study utilizes the latest census data (Census 2000), which is available to the public. County level census data were used for the analysis.

Limitations/Potential Impediments

1. One of the most important impediments may be the result of the survey questionnaire since it is not possible to control the responses of the surveyors.
2. The study includes only academic geography departments in four-year public education institutions. It is not possible, or just too difficult, to include the characteristics of GIS education in other academic departments.

C. ASSUMPTIONS

The following assumptions were made prior to the study:

1. It is assumed that most GIS programs are in the Geography Departments of higher education institutions in the United States.
2. It is assumed that a 50-mile range from the GIS institution can be considered a reasonable local community, using Census 2000 data.
3. It is assumed that the Carnegie Foundation's Higher Education Classification provides the most complete and accurate classification of the universities.
4. It was also assumed that local interest in the GIS program affects the size and type of GIS education at the universities.

D. DEFINITION OF TERMS

Carnegie Classification

This term describes the Carnegie Classification of Institutions of Higher Education, 2000 Edition, a well-known and documented classification in use since 1973. It is updated periodically by The Carnegie Foundation for the Advancement of Teaching, and classifies colleges and universities into one of 13 groups and sub-groups based on

graduate offerings, enrollment, budget and research funding.

County-level Population Data from Census 2000

The census 2000 results are available from the United States Census Bureau on the Internet. American FactFinder provides easy access to all Census 2000 information, publications, and summary data. This research can create extracts and summary information for geographic areas and can generate maps on line. The Census 2000 county data used in this study were taken from http://factfinder.census.gov/home/en/pldata.html.

Socioeconomic GIS Applications (Vector)

In GIS, geographic variations must be represented in terms of discrete elements or objects. The rules used to convert real geographical variations into discrete objects are the data model. A data model can be defined as a set of guidelines for the representation of the logical organization of the data in a database (consisting) of named logical units of data and the relationships between them. Current GISs differ according to the way they organize reality through the data model. Each model tends to fit certain types of data and applications better than other models. The data model chosen for a particular project or application is also influenced by the software

availability, the training of the key individuals, and historical precedent. The vector is the GIS model most applicable for socioeconomic studies. The vector GIS builds a model of the real world from points, lines, and regions. Points are positioned according to a location reference system such as latitude-longitude, the Universal Transverse Mercator (UTM), or State Plane Coordinate System (SPC). The application determines the level of precision. Points represent discrete objects such as sample points. A line segment represents discrete objects such as boundaries, streams, and roads. Cropped areas, parking lots, etc. are represented by closed line segments (areas or polygons).

Environmental Applications (Raster)

The raster model is the application most often used for environmental studies. The raster GIS references phenomena by grid cell location in a matrix. The grid cell is the smallest unit of resolution and may vary from centimeters to kilometers depending on the application. This model divides the entire study area into a regular grid of cells. Each cell has a specific order of cells, and each cell contains a unique value. Every location in the study area corresponds to a cell in the raster model. One set of cells and associated values is a layer.

Degree Programs in GIS

Many universities entered into GIS education at different levels such as offering individual courses, certificate programs, etc. Some universities, however, have focused on and offer more extensive and intensive GIS education. "Degree programs in GIS" includes bachelor, master, and doctoral programs.

Distance Learning in GIS

Some higher education institutions and some vendors have started to offer courses on the Internet. Distance education may be established using different formats. The most popular one is offering courses, certificate programs, and training on the Internet or via closed circuit TV.

E. RESEARCH QUESTIONS AND HYPOTHESES

The following research questions were analyzed in the study:

1. Which universities deliver GIS education and where are they located? What levels of GIS courses are offered (graduate or bachelors)? What types of programs do they have (degree, certificate, certification, etc.)?
2. Are there any similarities or differences in GIS programs at higher education institutions according to the classification of the Carnegie Foundation? Is there any

relationship between the type of higher education institution and the GIS program?

3. Do the graduates of GIS programs stay within the local area to work (within 50 miles) or leave the area to work in other parts of the nation?
4. Which geographic regions in the US have the most GIS programs? What factors affect this location concentration/pattern? What does the spatial distribution of the GIS institutions show us?
5. Most geography departments are in public institutions, so they are intended to serve the tax-paying population in the area. How do they serve the state and the community? What are the characteristics of the population they serve?

The following hypotheses were also tested:

1. Doctoral/research universities have larger GIS programs than baccalaureate and master's colleges.
2. Most GIS graduate programs are in research universities while terminal undergraduate GIS programs are in small universities.
3. Socio economic and environmental GIS applications are offered equally in all types of GIS programs.
4. After offering GIS courses, the enrollments of an academic department increase.

5. Distance GIS education has been offered mostly by a few large research universities since they have large numbers of support personnel and more facilities to support such activities.
6. An institution offering GIS designs its programs for the demand of the local market. Most rural institutions offer agricultural applications while the urban institutions offer more theory-oriented applications. In addition, GIS institutions offering GIS education show an even distribution in each region in the US.
7. There is a direct relationship between local population/market and GIS education. Most graduates serve the local market since the institution designed its program for the local market.

Table 1

Organization of the study

Research Question No	Hypothesis	Method	Display
1	1, 2, 3, & 5	Descriptive St. Analysis	Map and Tables
2	1 & 2	Descriptive St. Analysis	Maps and Table
3	7	Correlation	Map
4	2,4, & 6	Descriptive St. Analysis	Map
5	6	Correlation Co.	Map

F. PROCEDURES

Data Sources

Data for this research were obtained from the US Commerce Department, Census Bureau (Census 2000, County Data (Appendix B)), and a survey sent to the departments of geography (Appendix A). In addition, Carnegie Foundation's Higher Education Classification was used (Appendix C). However, the primary data sources were Census 2000 data and survey questionnaire sampling results. Census 2000 data is readily available for each state at the county level. The survey questionnaire was sent to geography departments in academic institutions in the US. After data had been compiled from the questionnaire, tables were developed to use for statistical analysis.

A directory for the geography departments in the United States universities was created as a spreadsheet. The directory included the name of the institution, state, city, the highest degree that institution offers (bachelor, masters, or doctorate), classification of the institution according to Carnegie Foundation (Doctoral Research Universities-Extensive, Doctoral Research Universities-Intensive, Master's colleges and Universities I & II, Associate Colleges, specialized institutions, and

Baccalaureate Colleges-General), and control of the academic institution (public, private) (Appendix C). The target institutions were 4-year universities. The institutions were chosen from the Association of American Geographers (AAG) directory 2000. The AAG directory had 237 geography departments.

For the second step, a survey questionnaire was prepared (Appendix A). It was sent by e-mail to all departments in the directory. The questionnaire was intended to get information about GIS education within each department. Its intent was to elicit information about students and faculty at the university, the program in GIS, and the current status of GIS education. The questionnaire was emailed directly to the head of each department. It was posted on the web page of the Department of Geography at Oklahoma State University. In order to get enough responses (25% of the total or more), another email was sent to all non-respondents after five days.

Treatment of Data

After securing enough responses to the questionnaire from geography departments (forty-five percent of the total), all responses were entered into the spreadsheet and statistical analyses were run. The maps that were produced

help to show the spatial distribution of GIS education and its characteristics in the US.

Several statistical methods were used to analyze the data in order to answer the research questions and test the hypotheses mentioned above. This study was based on descriptive statistical analyses, which are the set of concepts and methods used in organizing, summarizing, tabulating, depicting, and describing a collection of data. The goal of the descriptive statistics in this study was also to present the results of the research in tabular, graphical, or numerical forms.

Frequency distributions of the GIS programs were analyzed to determine the characteristics of the programs. Graphical representations of the frequency distribution of GIS programs also were depicted (Research Questions 1, 2, and 4).

In addition, the study presents introductory statistical analyses such as variability in the types of universities and of GIS programs at the universities.

For comparison between local businesses and GIS-education institutions, census data was used. The population within 50 miles of the GIS education institution was analyzed in order to see whether there is a relationship between the graduates of the programs and the

local economy, services, and business. The study looks at characteristics of the correlation coefficients (linear, positive, or negative) between graduates and the local population (research questions 3, 5, and 6).

The data was analyzed to determine the location of certificate programs, the total number of certificate programs in the US, academic units sponsoring certificate programs, courses (required and elective courses), focus of the programs, target of the programs, the number of certificate programs in each state, and the distribution of the programs in the US.

Tables were saved in a database in order to export to ArcView GIS, Which uses the shape file of the states and counties of the United States, (A shape file stores all of the necessary geometric, locational, and attribute information of geographic features (points, lines or polygons).) The attribute tables (tables that have tabular data) were imported to ArcView GIS to join the shape files. The output was displayed as different maps.

Organization of the Study

The study is organized as follows:

Chapter I	Introduction
Chapter II	Review of related literature
Chapter III	Descriptive data and answers to the research question
Chapter IV	Analysis of data and hypothesis testing
Chapter V	Summary, conclusions, and recommendations
Bibliography	References
Appendices	Detailed data analyses, maps, and survey instrument

Chapter II contains a review of similar studies showing important outcomes related to different GIS educational programs. It includes literature that reports the results of similar research and gives ideas about GIS education in the US. Chapter III contains basic results of the research questions. Chapter IV includes the detailed analyses of the information and data found in the study and reported in Chapter III and the results of the tests performed in relation to the research hypotheses. Finally, Chapter V concludes the study with an overall summary,

conclusions, and recommendations for further research taken from the analyses described in Chapter IV.

Summary

The increase in applications of GIS in many areas will require the same rate of increase in GIS education and training in order to supply the demand. However, currently there is no specific design or framework for GIS education nationwide. GIS education needs a structured framework that brings together interdisciplinary coursework and GIS to suit the needs of academic institutions and the business communities that draw on university graduates with GIS experience.

Chapter II

REVIEW OF RELATED LITERATURE

A. INTRODUCTION

A great deal of effort has been devoted to the search for a model for GIS instruction. Universities and professional organizations have organized conferences related to GIS education at university and K-12 levels. The weaknesses and strengths of the GIS programs in colleges and universities have been discussed many times, especially at undergraduate and graduate levels.

Dahlberg (1983), Sullivan and Miller (1991), Aageenbrug (1992), Morgan (1987, 1991, 1992, 1993), Hamm (1994), Dale (1994), Strobl (1995), Obermeyer (1992, 1994, and 1997), Obermeyer & Pinto (1994), Wikle (1994 and 1998), Kemp (1997, 1997, and 2000), and Huxhold (1996 and 2000) have studied GIS education from different perspectives.

Dahlberg (1983) explained cartographic and geographic information systems education in the United States using a "pancake with bubble" model. The pancake represents the introductory level of courses in GIS, which are offered in many colleges and universities. The surface bubble represents the places where advanced courses are offered.

He also notes a pyramid structure with numerous intermediate courses.

There are many driving forces for GIS education today. Government initiatives, threats of competition from related organizations, and leadership interests in establishing benchmarks of performance are just a few of the driving forces. At the same time, more attention is focused on the competence of the employees, which can be solved with certification (Phillips 1987).

According to Obermeyer (1997), the demand for GIS education comes from three different groups:

1) Those who work in the discipline.
2) Those who desire to work in the discipline.
3) Employers who believe the existing educational programs are not meeting the educational needs of employees.

Obermeyer (1997) emphasizes that GIS education is a great benefit to individuals who want to work in a discipline without an academic degree. In addition, GIS education assists governmental agencies and corporations in identifying qualified individuals to conduct ecological and planning studies (Burley 1993).

GIS education is attractive for employees because it offers opportunities for a higher salary, improving their

performance, and finding good jobs (Obermeyer n.d.). Some universities which had already established GIS programs were both pioneers in teaching GIS (i.e. Harvard University), and in developing early GIS programs. In Great Britain, Edinburgh University was the pioneer in GIS education. In Canada, the Department of Geography at the University of Western Ontario was the first institution to offer formal GIS education. Some universities in the United States and the UK offered degree programs in GIS. Few educational institutions offered GIS programs before 1990 in the United States; however, many universities started GIS education in the second half of the 1990s. Many universities did not have the capability to support GIS course work and very few were able to support a large multiple curriculum in Cartography, Remote Sensing, and Geographical Information Systems (Aageenbrug 1992).

The development of GIS depends on new technologies, including GIS software. Since the 1980s, many new software programs have been developed, and this trend will continue. Because of this fast development, many GIS users have had problems keeping up with new technology. Jack Dangermond (1987) stressed that his company's efforts to improve ArcInfo had been adversely affected by a lack of individuals who were educated in GIS. This development had

created a need for more people who were good at data collection and storage and the display of spatial data (Morgan 1987).

Three forms of GIS programs have been commonly applied by academic departments. They are short courses and workshops provided by vendors and universities, certificate programs and certification, and degree programs. Short courses and workshops are generally product-training courses, and these courses are directed towards a single software package. They contain general information about the software package without depth because of the short time duration. Even though GIS vendors have been very active in providing short courses, academia and universities have been oriented to more extensive GIS training and education. However, the efforts are not sufficient and there is still a need for a framework to help professional development in the subject.

Software vendors, employers, vocational schools, colleges, and universities have all been conducting GIS education and training. These organizations have established different programs in terms of quality, depth, focus, and duration. According to Wikle (1998), "GIS practitioners" have a professional identity that they did not have 20 years ago. Unfortunately, the most neglected

part of GIS has been the education and training of individuals (Sullivan and Miller 1991). GIS analysts, GIS specialists, and GIS project managers are increasingly common in industry and government. On the other hand, in some large agencies and companies, GIS practitioners may suffer from an identity crisis because supervisors and other officials have little understanding as to what GIS practitioners do. At the same time, less qualified individuals who represent themselves as GIS experts may tarnish the reputation of GIS practitioners.

According to Huxhold (1996), two types of students want an education in GIS.

1. Those who plan to use it within a specific profession,
2. Those who want to enter a career as a "GIS professional."

In 1996, Huxhold reported that more than 800 university departments internationally offered (or planned to offer) GIS courses. For the second group (GIS professionals), few academic institutions offered GIS programs integrated with technology.

B. TYPES OF GIS EDUCATION

Short Courses and Workshops

Short courses and workshops were common during the early period of GIS growth (Wikle 1998). They are organized for explicit goals within a short time frame, and most of the times do not have any prerequisite courses. Employers often assign short courses during the hiring process in order to give information about the software programs that employees will use. At the same time, many universities, like Salem University, and some software companies (Environmental Systems Research Institute (ESRI)) offer short courses and workshops to give basic knowledge about software and specific applications.

Distance GIS education

Distance learning is becoming popular in GIS education in the US, Canada, and Europe. This is a relatively new learning method for those who do not have the opportunity to attend a scheduled GIS course. Students who register in distance GIS education take a sequence or group of courses on an independent basis that can often be counted toward a GIS diploma or degree program. Students can follow the course by video or Internet in order to allow for "facilitating self-paced instruction" (Wikle 1998).

Some universities in the United Kingdom (Manchester Metropolitan, Sanford, and Huddorsfield University) have been active in this teaching approach since mid 1980s (Kemp 1996). Likewise, Salzburg University, in Austria, has been offering GIS education via distance learning working toward a postgraduate diploma for home-based learners for several years (Strobl 1995).

Certificate Programs

Certificate programs are defined as programs at accredited colleges and universities that constitute a sequential pattern or groups of courses developed, administered, and evaluated by faculty or faculty-approved professionals (Smith 1987). Long (1992) defines a certificate program as "a non-degree sequence, pattern or group of instructional sections that focus on an area of specialized knowledge or information that is developed, administrated, and evaluated by the institution's faculty members or by faculty approved professionals" (p.17). By the 1990s, more than 600 colleges and universities had certificate programs in different subject areas (Henderson 1991). Certificate programs in general had begun to flourish in the 1970s as a response to specific technological and professional demands for concise and

concentrated studies at colleges and universities (Smith 1987 and Holt 1991).

Robinson (1991) notes that there was a large market for certificate programs, and the universities and colleges were not capturing as much of the market share as they could. Such programs were mostly similar to a traditional education and offered courses organized around a recognized conceptual base that had a set of criteria for matriculation, graduation, and assessment and a progressive and time-limited course of study. On the other hand, even though certificate programs in GIS have been increasing very rapidly, there has not been sufficient empirical research on how certificate programs benefit the individual practitioners (Morrison, 1994). According to Morrison (1994), support for certificate programs is coming from improvements in the standards of practice, increasing credibility, and increasing respect for professionals.

Certificate programs are usually under the umbrella of an academic institution that requires students to complete course work. Admission criteria are changed according to the design of the program. The programs may require attendance and prerequisite courses. The credit hour requirements also vary for different programs. Like degree programs, most professionals and researchers believe that

certificate programs need to be approved and supervised by a university or college (Wikle 1998).

The number of certificate programs increased rapidly (from 19 to 44), between 1996 and 1998. Course work demands ranged from as few as 12 credit hours to as many as 50 credit hours. Most GIS certificate programs are interdisciplinary in their approach and may require core courses in Geography, GIS theory, and Computer Science, as well as core or elective coursework in Civil Engineering, Remote Sensing, Database Management, Cartography, Photogrammetry, Statistics, GIS Project Management, and Planning. According to Wikle (1998), some of the issues in establishing GIS certificate programs are the focus of the program, faculty, fees, program management, certificate requirements, type of credits, student type, course availability, prerequisite courses, and designation of the certificate. Course work for certificate programs can include required and elective courses. The most common courses are "Introduction to GIS Theory" and "Cartography." Interestingly, some of the introductions to ESRI products, such as ArcView and ArcInfo, are also offered frequently as required and elective courses.. The title of certificate programs also varies from institution to institution. Even though institutions have different names for their

programs, most of the programs are very similar in terms of curriculum design except for the number of hours required.

The distribution of certificate programs in the United States shows similarities within GIS-offering institutions. California has the most certificate programs (6), including distance certificate programs. Certificate programs have also become common in the Northeastern United States. Canada also had seven certificate programs in 1998, four of which were in the province of Ontario (Morgan 1992 and Wikle 1998).

Certificate programs have some advantages for universities and colleges in attracting new customers (students and business contracts) and by increasing the ways that institutions can meaningfully serve business and industry (Robinson 1991). Each institution has organized its own program in terms of prerequisites and core courses. The majority of the certificate programs are interdisciplinary in their approach to course work and require at least one core course in GIS theory.

Dramowicz et al. (1993) gives two common approaches to GIS curriculum in any institution.

1- A linear sequence of courses, which builds and refines skills.

2- A matrix approach, which offers core courses and allows elective courses. Table 2 shows the structure or implementation of a GIS curriculum in a certificate program.

Table 2: Approaches to a GIS Certificate Program
(Adapted from Wikle 1998)

Linear approach to a Certificate in GIS (*College of Geographic Sciences, Nova Scotia Community College*)*

	First Semester
GIS 110	Fundamentals of Geographic Information Systems
RS 110	Fundamentals of Remote Sensing/Digital Image Processing
GIS 120	Introduction to Programming
CP 110	Introduction to Computers
	Second Semester
GIS 210	Advanced Geographical Information Systems
GIS 220	Information Systems
GIS 230	Spatial Modeling and Analysis
RS 210	Remote Sensing and Applications
RS 220	Advanced Image Processing
IS 450	Directed Studies

Matrix approach to a Certificate program in GIS (*University of Connecticut*)**

	Required courses
GEOG 301	Fundamentals of GIS
GEOG 303	Applications of GIS
	Two electives from the list below:
GEOG 312	Spatial Statistics
GEOG 382	Public Facility Location
GEOG 385	Advanced Physical Geography
GEOG 386	Environmental Evaluation and Assessment
NRME 238	Advanced Remote Sensing
NRME 377	Natural Resource Applications of GIS

*Program requires a BA degree in geography, forestry, science, engineering or a related field.
** Program prerequisites include a BA or B.Sc. degree with a 2.75 GPA or score of 1000 on the Graduate Record Examination.

There are three categories that institutions most often apply in designing such programs.

1- Specification of prerequisite courses, discussed by Kemp et al. (1992), Wikle (1994), and Maher and Wigtman (1985).

2- Specification of core courses needing to be taught, discussed by Goodchild (1991).

3- Elective courses, which balance education and training.

Certification in GIS

According to Obermeyer (1997), certification is a process in which a "candidate meets a specified set of criteria defined by a certification board." Wikle (1998) defines the focus as being on "explicit, measurable outcomes that require an individual to demonstrate competency and mastery of a body of knowledge through an examination or peer evaluation process." Likewise, certification is an indication that professionals or employees have a certain level of experience and knowledge about the topic. Obermeyer (n.d.) also states that it is a method to ensure that only qualified individuals may enter a profession. Certification gives professionals the opportunity to update skills and knowledge and recognizes professional qualifications in GIS (Unwin 1996).

Certification is voluntary and most programs are supervised by professionals. At the same time, competency among practitioners is maintained through licensing, a mandatory registration process through which the government gives permission to an individual to engage in an activity.

According to Huxhold (2000), there is no licensing or certification of GIS practitioners and professionals except ASPRS's certification programs (Certified Mapping Scientist, GIS/LIS). In 1999, the International Organization for Standardization (ISO) approved the development of a system for certification by a central independent authority consisting of personnel in GIS for each country. Certification is offered by professional organizations specific to a particular career. In recent years, software vendors have developed certification for their own software. Several academic institutions have also established GIS certification programs: Rutgers University, the University of Wisconsin-Milwaukee, San Diego State University, and the University of Minnesota (Obermeyer n.d.). These programs are in a variety of disciplines, like Planning, Surveying, Geography, and Social Sciences, at graduate and undergraduate levels in universities and community colleges. Currently surveying groups have been promoting licensing in GIS as well. ISO, URISA, and UCGIS

have developed committees to explore the potential for GIS certification at individual, program accreditation, and institutional levels.

C. ACCREDITATION

Accreditation "is at the institutional level, rather than an individual designation. It can be bestowed upon an academic program in recognition of meeting specific criteria" (curricula, personnel, qualities of the programs) (Wikle 1998 p.497). Standards for accreditation are a joint effort of academics who want to bring about a distinct level of program. The criteria for accreditation are established primarily for undergraduate science and engineering programs (Obermeyer 1997). An independent organization sends an inspection team to the institution. If the team is satisfied, the program receives accreditation. Accreditation is intended to ensure the competency and quality of individuals coming out of the educational process. It is an institutional designation for an academic program that meets specific criteria involving curricula, faculty members, qualifications, and facilities. Chrisman (1989) says that the success of accreditation will ensure a uniform, standardized product student from program studies. Professional organizations give accreditation for standardized programs. Once the institution is accredited,

it attracts more and better students. The solution for GIS education may be GIS certificate programs that tie together many courses and address this need for structure and recognition (Wikle 1998). However, there are some arguments against accreditation. The lack of an umbrella organization in GIS makes the accreditation issue difficult. It has not been easy to find enough people to develop accreditation standards and agree to participate in the process of accreditation (Obermeyer & Pinto 1994).

D. DEGREE PROGRAMS IN GIS

A few universities offer degree programs in GIS, and this number has been growing. For example, Texas A&M University at Corpus Christi initiated a Bachelor of Science in Geographic Information Science. South West Texas State University just started a new Ph.D. program in GIScience in 2002. On the other hand, a number of universities and colleges outside of the US offer degree programs in GIS, such as Canada, the United Kingdom, Austria, Australia, and New Zealand.

Edinburgh University, in the United Kingdom, the first university offering a Masters of Science (MS) and post-graduate GIS degree program in Europe, had enrollments of nearly 30 students per year in 1993 (Gittings, et al. 1993). The university has offered well-established GIS

courses since 1985. Moreover, the university has had a strong background in GIS-related studies since the 1980s. Postgraduate courses, both core and elective courses, cover a wide range of topics, which include remote sensing and photogrammetry, GIS database management, analysis and modeling, cartography, and applications of technology.

Leicester University, United Kingdom, began GIS courses in 1988. Both M. Sc. and diploma programs last ten months. Like Edinburgh's program, courses consist of compulsory courses, which deal with GIS principles and applications, data collection, computer programming, databases, cartography, and fieldwork components of the lecture program.

According to Gittings (1989), GIS education within university education is "worthy of consideration." The trends in student enrollment at Edinburgh University showed that the numbers had been increasing each year. He noted that the demands for GIS education increased greatly at Edinburgh University, even though some other universities had begun GIS programs. The graduates from Edinburgh University went to a variety of different areas. Most of the students' employment was with software vendors, national mapping agencies, surveying, university teaching, and research and contract research (Gittings 1989).

Curtin University, in Austria, has been offering a full undergraduate degree in GIS since 1992 and a diploma program since 1988. The main purpose of offering a degree in GIS, according to Curtin University geography faculty, is that the Department of Geography offers a major in GIS, not a minor in GIS, which gives some distinct advantages:

1) Graduates will have sufficient in-depth knowledge about GIS to work as developers of computational tools for Geosciences.
2) Studying in a degree program increases the students' awareness of the applications.
3) A degree program offers opportunities to teach the broader principles of geography (Gahegan 1996).

Massey University, in New Zealand, offers a diploma in GIS. The program aims to teach students how they can apply any software to solving a problem within an institutional context. The diploma program aims to give students a broad knowledge of GIS, which they can apply in the real world. The university requires some core courses along with some additional course work.

A new diploma program began in the School of Geography at the University of Leeds in 1998. The program has been designed to equip students with intellectual knowledge and skill to become specialists in the theory, methods, and

applications of GIS in Environmental Science. The program includes core and elective courses to give students opportunities to choose various specialized subjects of study.

E. CURRICULA IN GIS

A great deal of time has been devoted to developing a model for GIS instruction. Each year a series of conferences on education in GIS have been organized by the universities and professional organizations related to GIS education at university and K-12 levels. The weaknesses and strengths of the GIS programs in colleges and universities have been discussed many times, especially at the undergraduate and graduate levels.

There are many possible approaches to building a general outline or curriculum for teaching GIS. Currently, a variety of curricula have been developed. One of the most important was created by the National Center for Geographic Information and Analysis (NCGIA). The NCGIA's core curriculum consists of 75 units in three groups:

1- Introduction

2- Technical issues

3- Application issues

Ironically, most of the colleges and universities in the United States do not follow NCGIA's guidelines and core

curriculum for GIS education. Only 6.2 percent of the geography departments stated that they use the core curriculum guidelines in their programs (Morgan 1993). It is clear that most departments develop their own course schedules and curriculum. Other examples of GIS curricula include "curriculum development in Cartography and Geographic Information Systems" by the University of Washington, the University of Victoria's curriculum, and the GIS syllabus from the United Kingdom (Keller 1996). In addition, a matrix approach has been prepared by the Committee for Curriculum Development in Cartography at the University of Washington and Chicago Area Geographic Information Study (CAGIS).

Even if a basic GIS curriculum were not an issue, is it possible to formulate an optimal model for teaching GIS? The variety of GIS job opportunities, which require a unique combination of skills, casts doubt on the likelihood of developing a GIS program to satisfy all requirements. However, the College of Geographic Science (COGS) in Lawrence Town, Nova Scotia, has established its own very useful model of GIS education and training (Dramowicz et al. 1993). The college offers Photogrammetry (since 1960), Cartography (1961), Planning (1976), Remote Sensing (1977), Scientific Computer Programming (1980), and GIS (1985).

Annually more than two hundred students enroll in the program, and more than 20 instructors are on faculty. The program at COGS is oriented for students having at least completed a degree in a related field. Also, a twelve-month "scientific computer programming diploma program" was established. At the beginning, the college used the program POLYGRID, after which they switched to ESRI's program (ArcInfo). The GIS program has a closer integration with the program in remote sensing. The new format of the GIS/Remote Sensing program gives flexibility for those who wish a program in a shorter format and the ability to receive a certificate in either GIS or remote sensing at the end of two semesters. If the students want to continue, they can get a degree at the diploma level.

Aangeenbrug (1992) emphasizes how fast GIS has been growing in North America. In 1984, only 23 departments had faculty members specializing in Geographic Information Systems. By 1991, 137 programs in the United States and 28 programs in Canada listed GIS among their specialties. The fast growth emphasizes the need to clarify collegiate training and the educational goals and objectives of planning programs, which will depend on improvements in preparation of the GIS faculty. In the 1980s, few academic departments could afford the large expenditures necessary

to acquire software, hardware, and the staff to develop a GIS facility. However, this situation has changed with the inexpensive and powerful microcomputers and relatively cheap GIS software; therefore, colleges and universities are offering more GIS courses than ever before.

Morgan (1986, 1987, 1992, and 1993) has done important studies on GIS education, including his 1986 study of academic GIS education versus training. While the function of a university should be to educate students about GIS concepts, some government agencies and businesses are interested in bringing in students, even for entry-level positions, who have been trained in the use of a particular software package as part of their education. Morgan et al. (1986, 1992, and 1993) demonstrates that the number of departments that offer GIS and GIS-related courses has been increased each year. This group has conducted many surveys about GIS education. Their first attempt, in 1986, covered the departments of geography and landscape architecture. The results showed that only 54 percent of the geography departments offered GIS courses. The most important problems that departments had were the lack of staff and interest. The results also showed that the content of the academic GIS courses varied widely. The nature of geography, geographic data collection, geographic data

analysis, geographic data display, and types and uses of GIS were common aspects of course curricula. A majority (75%) of the departments surveyed showed that they did not have any prerequisite courses.

Departments used different software packages and hardware. Moreover, mainframe and microcomputer environments were frequently used rather than minicomputers. The software package used most frequently was MAP (Map Analysis Package) because it had many advantages when compared with the others: it was cheap, adapted to a mainframe, etc. ArcInfo was too expensive to be used by the departments in the late 1980s and early 1990s. Another problem was the lack of textbooks; instructors provided selected articles and handouts to students in order to solve this problem. However, the results of the 1993 survey (Morgan 1993) show that more than 400, and in the 1996 survey more than 650, colleges and universities in the United States and Canada offered at least one GIS course. Although geography departments have offered most of the GIS courses, GIS courses are available in many different departments, such as Civil Engineering, Urban and Regional Planning, Agronomy, Forestry, and Landscape Architecture.

Goodchild and Kemp (1992) write that GIS courses have become a common component of the undergraduate program, especially in geography departments. According to Morgan (1992), GIS related courses are offered in diverse academic units. However, roughly half of the courses (51 percent) were offered in the department of geography in the same year. Other units included urban planning, surveying, continuing education, agronomy, agriculture, etc. Certificate programs also have been sponsored primarily by geography departments (~35 percent), graduate colleges, and urban planning programs. Morgan et al. (1993) show that academic GIS programs at universities are offered at both the undergraduate and graduate level. While some departments do not require any prerequisite courses, others require prerequisite courses in computer programming and cartography. In addition, the use of a computer lab supports GIS education programs. Academic departments also have changed their GIS software packages over the years as new, cheaper, and better software programs have become available. According to Morgan (1992 and 1993), most departments used microcomputers (88 percent) and workstations (43 percent) for GIS-related courses and labs in the second half of the 1980s. They also used a variety of software programs: Idrisi (58 percent), ERDAS (21

percent), ArcInfo (45 percent), MAP and related programs (28 percent), and others (Atlas*GIS, GRASS, MapInfo, SPANS, etc.).

A survey by GIS World in 1995 provided some other very interesting results. The workstations supporting the GIS curriculum at most universities were predominantly UNIX workstations from SUN (50 percent). Intel-based machines dominated PC-based hardware, with 89 percent used in GIS curriculum. The computer lab operating systems were dominated by DOS (86 percent), Windows (79 percent), and UNIX (74 percent). However, during this time, Windows dominated heavily in GIS labs. Most computer labs had printers, plotters, digitizers, CD-ROMs, and optical devices. Videos were also becoming common in GIS labs. The survey showed that the academic uses of GIS software programs cover a wide range of products. Morgan (1987) showed that the share of ArcInfo was low in 1986 while it dominated as GIS software in 1995 with 80.5 percent. ArcView, Idrisi, MapInfo, Grass, ERDAS, AutoCAD, and Atlas* GIS were the other most popular software programs used by geography departments.

The availability of GIS textbooks also increased from previous years. However, the lack of textbooks was still a very important problem for GIS classes in 1995. Publication

of textbooks was increasing, and most of the textbooks were coming from ESRI, Star, Aronoff, Onward Press, and Burrough publications. The GIS World survey in 1995 showed that most of the research areas were in environmental science, geographical analysis, geology/soils, archaeology, agricultural natural resources, planning, remote sensing, transportation, and technological developments. In many areas, intensive research was being done using modeling, remote sensing, spatial analysis, spatial statistics, temporal analysis, user interface, visualization, global change, database issues, accuracy, and raster/vector techniques and technology. The trend shows that NSF (National Science Foundation), NASA, the Department of the Interior, the EPA (Environmental Protection Agency), Defense, Commerce, NOAA, Agriculture, and Forest Departments have provided a lot of support for GIS research in the USA. Most of the funding agencies are federal/national, state/provincial, private industry, and academic departments (Foresman 1995).

Canada is the second largest GIS-offering country in North America after the US. Almost 50 higher education institutions offer GIS-related courses in their curricula, mostly in Ontario and Quebec provinces. Studies have shown that GIS education was not strong in North America in the

early 1990s when it is compared to European countries (i.e. Germany and England). In other European countries, only a few universities were offering GIS courses. In Africa, only three countries had started GIS education (South Africa, Nigeria, and Zambia) by 1992. Moreover, Australia and New Zealand have relatively high rates of GIS education when they are compared with other countries in East Asia (Morgan 1992).

F. PROBLEMS IN GIS EDUCATION

Colleges and universities face many different problems when they decide to offer GIS courses. Morgan's (1992) survey shows that most of the problems were as follows:

1- The cost of software (61 percent): Even though new technology gives an opportunity to reduce the cost of software, some software programs were still too expensive for some departments.

2- The cost of hardware (65 percent): It is hard to buy sufficient computers and computer-related hardware for academic departments because of their budgets.

3- The cost of software/hardware maintenance (57 percent): Contracts were too costly for some small departments.

4- The lack of low cost, vector based GIS software and the lack of suitable GIS textbooks.

5- The lack of faculty educated in GIS. Most departments have just one faculty member who teaches GIS related courses.

In addition, GIS faculty have other problems within their departments. Because older faculty members' interest in computer technology is low, they do not encourage students to take GIS courses. In addition, faculty who teach GIS related courses outside of geography are offering GIS-courses from an interest in "teaching with GIS rather than teaching about GIS" (Morgan 1993). Morgan offers solutions for the problems in academic GIS education;

1- Software vendors should provide software and hardware to academic departments at a reasonable price.
2- More community colleges and university departments should be encouraged to offer at least one GIS course.
3- Publishers need to examine and produce new textbooks.
4- Faculty who teach GIS courses need to be aware of the developments around the country and the world in the area of GIS. They should follow regional, national, and international GIS conferences.
5- Faculty members should be encouraged to share GIS education ideas.

6- The organizations of geography, GIS, and Remote Sensing should provide or develop internship programs to help students.

Many professional GIS people and researchers think that the most important issue in GIS education is the development of a main framework for continuing education. A model of continuing education in GIS has been created by Dahlberg and Jensen (1986) (Table 3). The model covers knowledge-based maintenance, acquisition of specialized knowledge, and acquisition of foundation modules; programs (prerequisite and core GIS courses, GIS certificate or diploma, GIS certification and recertification); course examples; recognition and job level. Overall, the model demonstrates a continuing GIS education, from entry level to established professional.

Table 3

Dahlberg and Jensen's Model of Continuing GIS Education

Module	Acquisition of Knowledge of Foundation	Acquisition of Specialized Knowledge	Knowledge-Based Maintenance
Program	Prerequisites and Core GIS Courses	GIS Certificate or Diploma	GIS Certification and Rectification
Course Examples	Map Interpretation, Computer Cartography, Spatial Analysis, Physical Geography, Remote Sensing, Coordinate Geometry, Introduction to GIS	GIS in Natural Management, Socioeconomic Applications of GIS	Short Courses or Workshops for Professional Development and Rectification
Recognition		Certificate in GIS Certificate in GIS Project Management	Verified GIS Analyst Certificate GIS Project Manager
Job Level		Analyst Operator, Programmer, Technician	Senior Analyst Project Manager, Senior Programmer

Entry Level ⟶ Established professional

Chapter III

DESCRIPTIVE DATA AND ANSWERS TO THE RESEARCH QUESTION

A. PROCEDURES

Basic Data Compilation

The data for this study were obtained from various sources. The data for geography departments was compiled using Carnegie Classification and the Directory of Geography Departments from the AAG Catalog 2000. Each record in the file represents a different institution offering GIS instructional programs. The record contains the name of the institution, state, city, the highest degree the institution offers (bachelor, masters, or doctorate), the classification of the institution according to the Carnegie Foundation (Doctoral Research Universities-Extensive (DE), Doctoral Research Universities-Intensive (DI), master's Colleges and Universities I & II, Associate Colleges, specialized institutions, and Baccalaureate Colleges-General), and control of the academic institution (public, private). The target institutions for this study were four-year universities. The institutions were chosen from the Association of American Geographers (AAG) 2000

directory, which lists 237 geography departments. The file described here was used for sending questionnaires and as the population for the study.

The secondary data set for this study was developed from Census Report 2000 (US Commerce Department, Census Bureau), which is readily available for each state at the county level. The data for each county was downloaded from the US Census Bureau's web page in Microsoft Excel data format. Each record in the data set contains the County FIPS, County Name, Population, and State Name. The county level census data was then exported to ArcView GIS 3.2 for various spatial analyses. This file was used to determine and set the characteristics of the local population within 50 miles of each institution and compare between institutions to see whether the type of education varies from institution to institution.

The third form of data used in this study was the Carnegie Classification system, which categorizes each institution. This file was used to construct the survey questionnaire file and also to analyze GIS education at different types of institutions in order to determine similarities or differences between institution types. This data set included all Geography Departments in the United States; the record for each geography department contained

the regional division, control of the institution (public or private), state, state code, degree programs offered, and Carnegie Classification code DE, DI, M-I, M-II, BG, and BL.

The fourth major research file was constructed from the questionnaire and used to analyze each of the 13 questions in the survey. Ninety three out of 237 institutions submitted answers to the questionnaire (40 percent). The answers to the survey were compiled using Microsoft Excel. In addition, a chart was generated from the responses for each question. This file also contained the institution name and the name of the person completing the form, as well as the responses. The records in the file were used to determine and analyze specific characteristics of the departments and GIS education in the US; they were also used for the chi-square tests to determine if a significant difference exists between observed frequencies. In addition, this data set was used to produce maps showing the spatial distribution of the GIS institutions and individual tables were created for each question, the regional distribution of GIS institutions, the types of GIS institutions, the control of the institutions, the frequency of the Carnegie Classification in GIS

Institutions, and the frequency of the GIS degree programs (Appendix E).

After the compilation of these files, each file was processed using the appropriate research methods discussed in Chapter I. The data used in the study represent the entire known population of GIS education programs in geography departments at public and private institutions of 4-year higher education institutions in the United States.

Treatment of Descriptive Data

The data was analyzed in several ways. These methods included the compilation of the geography programs in different regions of the US with different characteristics of the universities to see how large the programs are and how GIS education affects the geography program in the institution. Questionnaire responses for each institution were also compiled, and are presented in the subsequent tables and in the appendices.

B. PRESENTATION OF DESCRIPTIVE DATA

Geography Departments offering GIS Education in the Higher Education Institutions

Table 4 shows the number and the percentage of the GIS institutions according to Carnegie Classification of the Higher Education Institutions. The responding institutions which offer geography programs represent a variety of Carnegie levels: one Associate College, six Baccalaureate Colleges (General), ten Baccalaureate Colleges (Liberal Arts), 36 Doctoral/Research Universities (Intensive), 89 Doctoral/Research Universities (Extensive), 89 Master's Colleges and Universities (M-1), three Master's Colleges and Universities (M-II), and three specialized institutions. The majority of the geography departments in the list offer geography at either the master's or Ph.D. levels (144 out of 237). Only 93 institutions offer geography at the bachelor's level alone. As can be noted, the four-year institutions offer a much higher percentage then two-year colleges (only 7.5%). Table 4 shows that Research Universities I & II (DE & DI) offer the majority of the GIS programs (52%). A lower percentage of the GIS programs are offered at small colleges because they may have more financial, technological, and academic challenges. Thus, this information provides a better

understanding of the patterns of the type of higher education institutions and GIS education.

Table 4

Number of GIS programs at different types of Higher Education Institutions in the US.

Carnegie Classification*	Number of GIS Programs	Percentage of GIS programs (%)
DE	**89**	**37.55**
DI	**36**	**15.18**
AC	1	0.42
BG	6	2.53
BL	10	4.21
M-I	**89**	**37.55**
M-II	3	1.28
SO	3	1.28
Total	**237**	**100**

*DE: Research Universities-Extensive
DI: Research Universities-Intensive
AC: Associate Colleges
BG: Baccalaureate Colleges—General
BL: Baccalaureate Colleges—Liberal Arts
M-I: Master's Colleges and Universities I
M-II: Master's Colleges and Universities II
SO: Specialized Institutions— Other specialized institutions.

The other information in Table 4 shows that almost 40 percent of GIS programs were offered in Master Colleges-I while only 1.28% of GIS programs were offered in Master Colleges II.

Spatial Distribution of GIS Institutions

The regional divisions used in this study are based on the Association of American Geographers' regional classification. According to this classification, there are nine regional divisions in the United State (Map 1). GIS education characteristics differ among the geographical divisions. Table 5 shows the number of the GIS institutions in each regional division. As seen in this table, the majority of the GIS institutions are in the Pacific Coast, West Lakes, and Southeast divisions. The Southwest division, on the other hand, has the lowest ratio. In addition, the Northeastern United States and Lakes Regions show even distributions of GIS offering institutions (Map 2). The Great Plains-Rocky Mountains division is the largest though it has fewer GIS institutions than other divisions (8%). Normally, the level of the expectation is that if a regional division has quite a high population and level of industry, the number of GIS education institutions will be high (West Lakes, Pacific Coast, Southeast, and Middle States).

Map 1

Geographic Divisions of USA According to
Association of American Geogrpahers

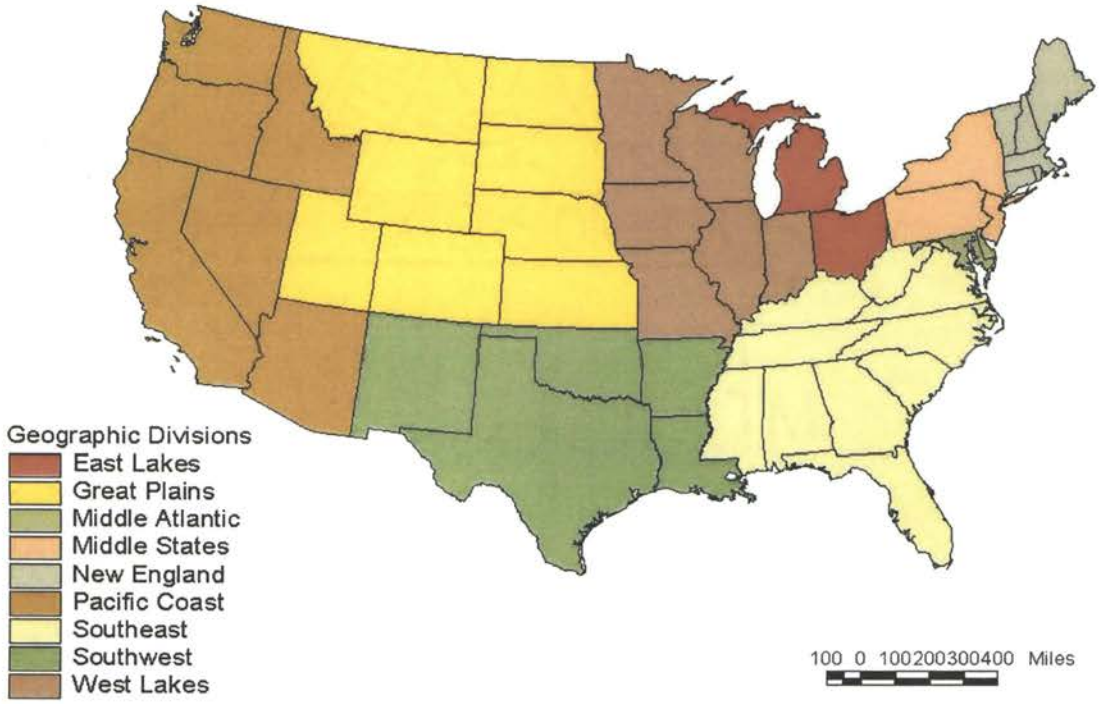


Table 5 shows one low extreme value, which is the East Lakes region. Even though the population and level of industry are high there, the size of the division is very small, covering only two states. However, the region has quite a large population. The Great Plains and Southwest divisions are large in size but the population density is low compared with other regions. Thus, it is logical that the numbers of GIS institutions are lower (14%).

Table 5

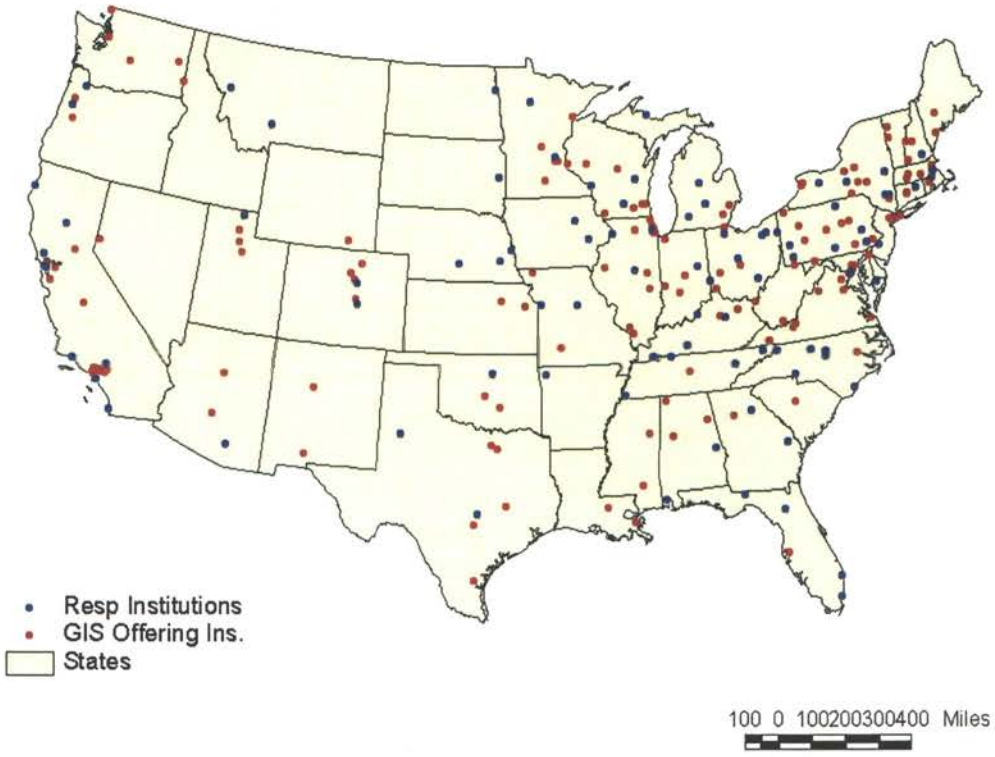
The Spatial Distribution of the GIS Education Institutions by Regional Divisions

Regional Divisions*	Number	Percent (%)
Pacific Coast Division	**37**	**15.61**
Great Plains-Rocky Mountains	19	8.01
Southwest	15	6.32
West Lakes	**44**	**18.56**
Southeast	**44**	**18.56**
Middle Atlantic	**10**	**4.21**
Middle States	32	13.53
East Lakes	17	7.2
New England- St. Lawrence Valley	19	8.01
Total	**237**	**100**

*Regional division in the table is derived from Association of American Geographers (AAG).

Map 2

Spatial Distributions of GIS Offering Institutions



The Size and Control of the Geography Programs Offering GIS Education

One of the questions concerned the level of the universities housing geography departments according to Carnegie Classification. Table 6 presents the distribution of the geography departments offering GIS education at various Carnegie levels. As can be noted from the table, almost 60 percent of the geography departments offer GIS education at the graduate level in geography.

Table 6

Profile of Geography Departments Offering GIS

Programs	Frequency	Cumulative Percentage
Bachelor in Geography	93	39.2
Master in Geography	80	33.8
Doctorate in Geography	64	27
Total	**237**	**100**

The Control of the Institutions

The majority of the private institutions offering GIS are in the Northeast and West Lakes divisions (Map 3 and Appendix F). Table 7 compares the ratios for control of the GIS education institution for private and public institutions. As can be seen from the table, only 29 are private, not for profit universities while 208 out of 237 institutions are public universities. More than half of the

private institutions are Doctorate Research I & II universities, according to the Carnegie Foundation while nearly 40 percent of these private institutions offer geography at the graduate level (masters & doctorate). Some of these are private institutions of long standing, with strong educational reputations, such as Johns Hopkins University, George Washington University, Syracuse University, and Clark University.

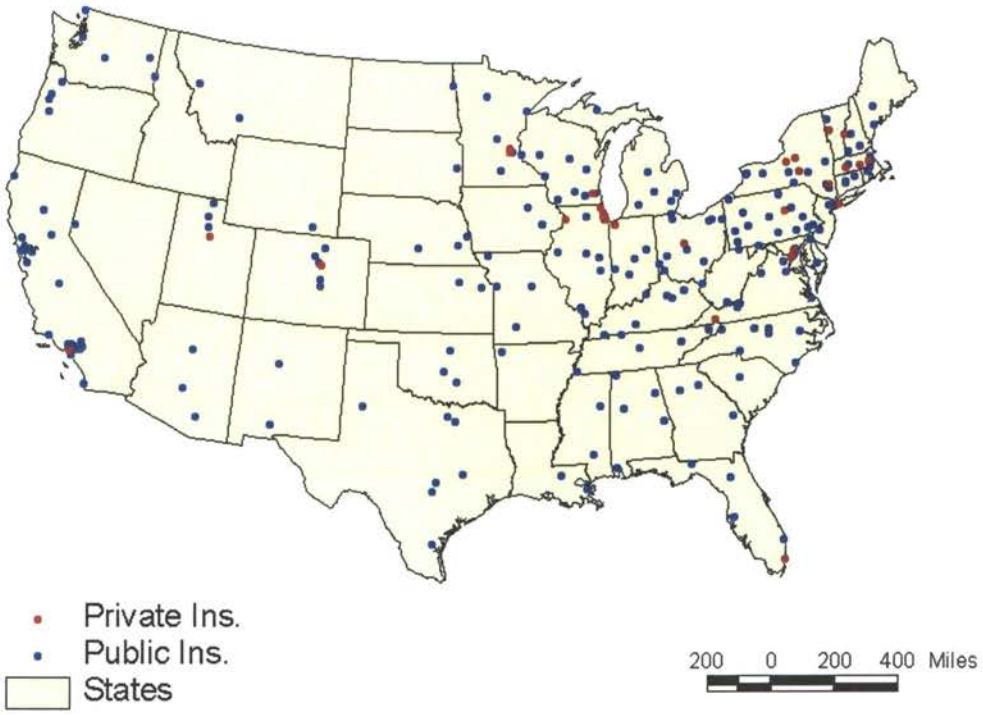
Table 7

Control of the Geography Departments Offering GIS Education

Control of The Institution	Number	Percent
Private	29	12.24
Public	208	87.76
Total	**237**	**100**

Map 3

Control of the Institutions offering GIS Education



Regional Distribution of the GIS Institutions

It is important to know where GIS education is offered or which geographic region dominates GIS education. Map 4 and Table 8 show the spatial distribution of geography departments which offer GIS education within each regional division. According to Table 8, the majority of the GIS education programs are offered in West Lakes (44 institutions), Southeast (44 institutions), and Pacific Coast divisions (37 institutions). One interesting observation from table 8 is that nine out of 29 private institutions are in the West Lakes region. Similarly, though the Middle Atlantic division is geographically small, six of the GIS education institutions are there. The Southwest and Great Plains-Rocky Mountains divisions offer the least GIS education when compared with the population and the size of the divisions. It can be noted that the majority of the institutions are located in the highly populated East, North, and Western United States.

Map 4

Regional Distribution of GIS Offering Institutions

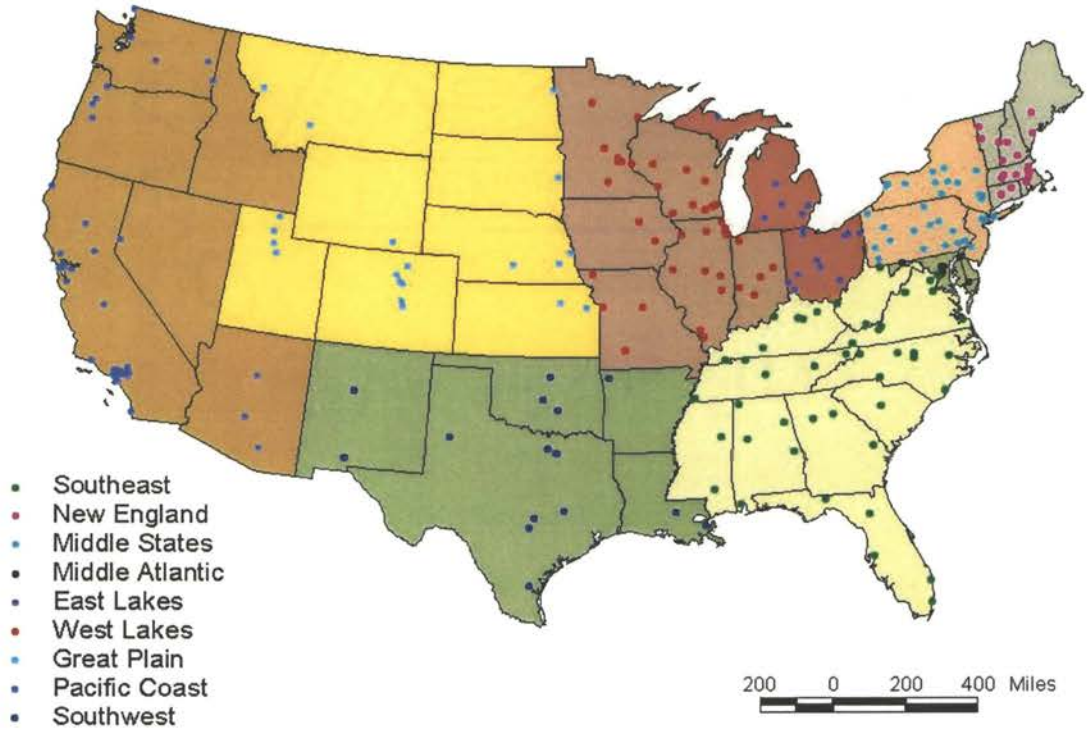


Table 8

Regional Distribution of GIS Programs According to Control of the Institution

Regional Divisions	Public	Private
Pacific Coast Division	**36**	1
Great Plains-Rocky Mountains	17	2
Southwest	15	0
West Lakes	**35**	**9**
Southeast	**42**	2
Middle Atlantic	7	3
Middle States	**26**	**6**
East Lakes	16	1
New England-St. Lawrence Valley	14	5
Total	**208**	**29**
Total	**237**	

Tables 9 and 10 present the characteristics of the geography departments in different divisions. Most of the geography programs offering bachelor's level programs are located in the West Lakes, Southeast, and Middle States regions while master's and doctoral level institutions are in the Pacific Coast and Southeast divisions. Only three institutions offer GIS at the bachelor's level in the southwest division. The West Lakes and Southeast divisions are similar as to the types of educational programs they have.

Carnegie Classification provides some further insights into the spatial distribution of the GIS institutions. Table 9 and 10 show the types of institutions and their

distributions in each division. The Southeast division has the highest number of Doctorate-Research institutions (26 institutions) while Middle the Atlantic division has the fewest (five institutions). The Pacific Coast, West Lakes, and Middle States regions have similar numbers of master's colleges.

Table 9

Regional Distribution of GIS Programs According to the size of the Institution

Regional Divisions	Bachelor	Master's	Doc.	Sum
Pacific Coast Division	8	14	15	37
Great Plains-Rocky Mountains	5	8	6	19
Southwest	3	5	7	15
West Lakes	**21**	13	**10**	**44**
Southeast	**18**	**16**	**10**	**44**
Middle Atlantic	4	2	4	10
Middle States	**18**	10	4	32
East Lakes	6	7	4	17
New England-St. Lawrence Valley	10	5	4	19
Total	**93**	**80**	**64**	**237**
Total		**237**		

Table 10

Regional Distribution of GIS Programs According to the Type (Carnegie Classification) of Institution

Regional Divisions	DE	DI	AC	BG	BL	SO	M-I	M-II
Pacific Coast Division	**14**	4	1	0	0	0	**18**	0
Great Plains-Rocky Mountains	8	5	0	1	0	1	3	1
Southwest	10	3	0	0	0	0	2	0
West Lakes	**13**	**7**	0	2	2	0	**19**	1
Southeast	**19**	**7**	0	1	2	0	15	0
Middle Atlantic	4	1	0	0	0	0	5	0
Middle States	7	2	0	1	4	1	**17**	0
East Lakes	8	5	0	0	1	1	3	0
New England-St. Lawrence Valley	6	2	0	1	1	0	7	1
Total	**89**	**36**	**1**	**6**	**10**	**3**	**89**	**3**
Total					**237**			

Characteristics of the Survey Responses

The results of this survey are based on 237 colleges' GIS education programs chosen from a list compiled from the Handbook of AAG 2000. The respondents were asked to provide qualitative and quantitative answers to a broad range of questions about their GIS education program. The full questionnaire is in Appendix A. The questions concern the type of GIS education, size of the program, impact on student enrollment, and relationships between the GIS education program and the market. After securing enough responses (40 percent of the total) to the questionnaire, all responses were entered into a spreadsheet (Appendix D). The responding institutions were categorized according to

Carnegie Classification, Regional Division (according to AAG Classification), the control of the institutions (private or public), and the degree that institutions offer (bachelor's, master's, or Ph.D.).

Those institutions that responded have similar population characteristics. More than 50 percent of the institutions (49) were either Research-I or II universities. The rate of the M-1 Universities is also quite high compared with other colleges (Appendix E).

The percentage of institutions offering masters and Ph.D.'s in geography is also more than the percentage of institutions offering a geography degree at the bachelor's level (58 Percent). Only eight private institutions responded to the survey, which is a rate similar to our population.

Most of the responses were from the Southeast, West Lakes, Middle States, and Pacific Coast divisions. The Southwest and New England divisions had only four respondents each.

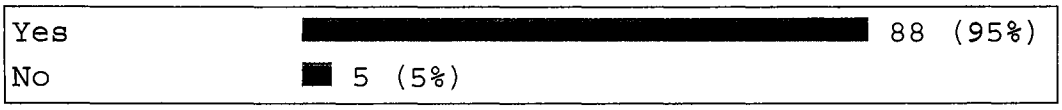
According to the survey results, 95 percent of the institutions offered GIS courses within the last two years, while only five institutions did not offer any courses in GIS during this time period (Chart 1). All of these institutions were public universities with Research I (2)

and Research II (2) classifications, and one associate college (College of Alameda-California. Two bachelors, two masters, and one doctorate geography department did not offer GIS courses.

The Size of the GIS Programs

Almost half (48 percent) of the geography departments offering GIS education have fewer than 50 students in GIS courses while one fourth of the institutions have between 50 and 100 students (Chart 2). Programs having more than 100 students (25 percent) are classified as large programs.

Chart 1
Courses Offered Last Two Years



Institutions having large GIS programs are all public institutions except one (St. Paul University-Minnesota). According to the Carnegie Classification, all programs having more than 100 students in GIS are in Doctoral Research Universities except for six institutions that are Master Colleges and Universities-I. Four large GIS programs were offered at the bachelor level only.

The number of students and of courses offered in geography programs show identical results (Chart 3). Similar to the student profile, almost half of the institutions offered at most four GIS courses in 2000. Programs offering between four and six courses (more than 25 percent) were classified as medium-size programs. Programs offering more than seven courses in a year are classified as large programs, and almost 25 percent of the programs offered more than seven courses in the year 2000.

Chart 2

Number of the Students in GIS Education at Each Program

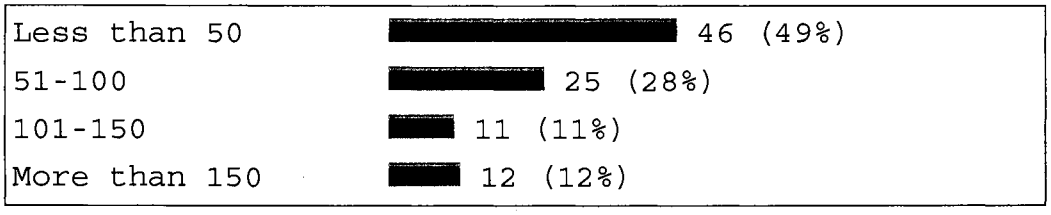
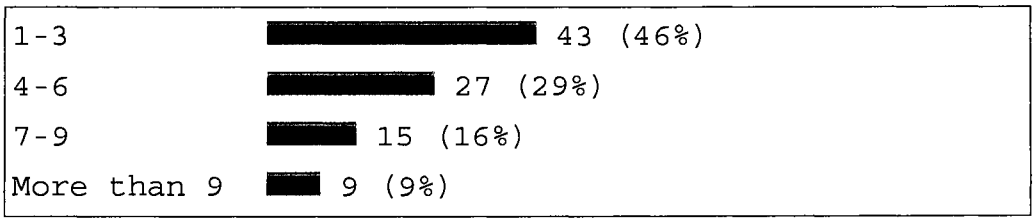


Chart 3

Number of GIS Courses Offered during Spring, Summer, and Fall 2000

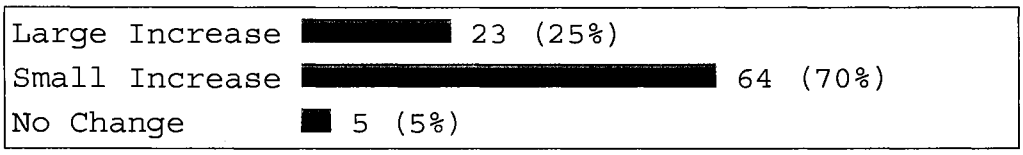


The Impact of GIS Education on Geography Departments

The overwhelming majority (94 percent) of institutions agree that GIS education has increased enrollment in their overall programs However, the majority of the geography programs report that GIS programs caused a small increase while 25 percent report that GIS led to a large increase (Chart 4). Most of the master colleges reported that GIS education did not make any change to their programs.

Chart 4

Increase of Student Enrollment to the Department after GIS Courses Offered.



Distance Learning in GIS

Distance GIS education is quite new and very few institutions offer this type of program. Only five geography departments surveyed (six percent) offer distance GIS education. All geography departments offering distance GIS education offer the masters or doctoral diploma and the institutions are either doctoral research universities or master's colleges (Chart 5).

Types of GIS Education

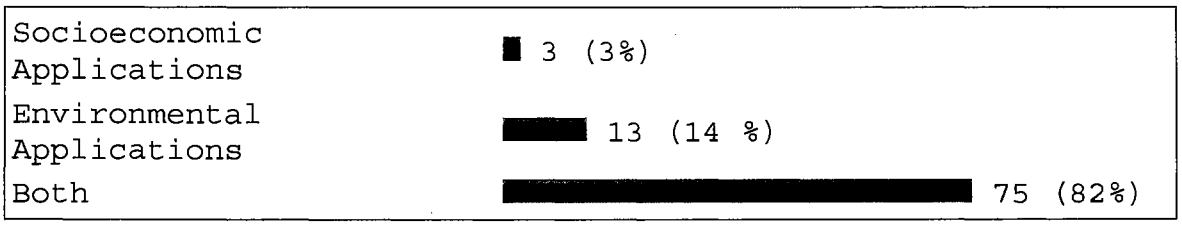
According to the survey results, most academic departments (83 percent) offer GIS courses in both socioeconomic (vector base) and environmental (raster base) applications. Only three institutions offer courses in socioeconomic applications alone (3 percent) while environmental applications alone were offered by only 14 percent (Chart 6). It is clear from the survey results that most GIS programs offer both environmental and socioeconomic applications (82 percent).

Chart 5

Distance Learning in GIS

Chart 6

Types of GIS Education Courses Offered by Institutions

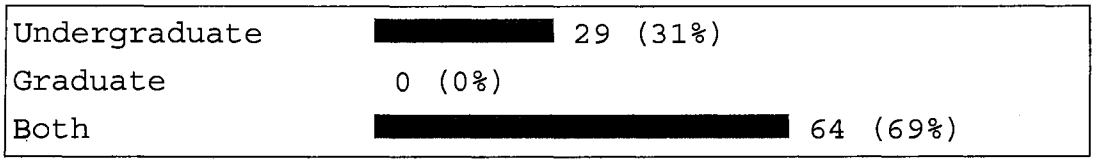


Level of GIS Courses Offered

The majority (69%) of the universities offering GIS education are offering it at both the undergraduate and graduate levels while only 31 percent of the academic programs offered only undergraduate level GIS instruction (Chart 7). No institution offers only graduate level GIS education. Six out of 29 private institutions (20%) offer only undergraduate GIS education while 23 public institutions (18%) offer undergraduate level GIS education. The institutions offering only bachelor's level GIS education are mostly small colleges, M-I and some D-I institutions according to the Carnegie Classification.

Chart 7

Level of GIS Courses Offered at the Academic Programs Surveyed.



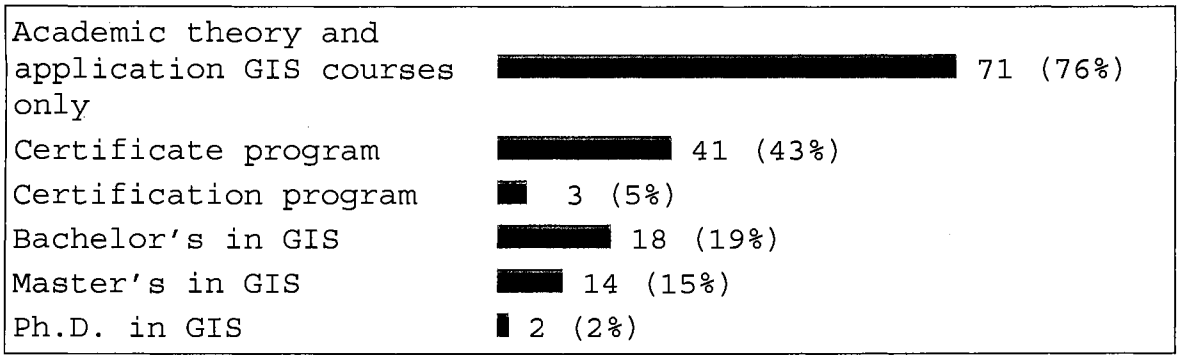
The Types of GIS Programs Institutions Offer

Twenty-eight academic departments responded that they have GIS certificate programs while only three departments offer GIS certification programs (Chart 8). Fourteen out of 237 Universities offer masters programs in GIS while only

19 departments offer bachelor's level programs. According to the survey results, 76 percent of the institutions offer academic theory and applications in GIS, and it may be offered at any level (bachelor or graduate). The majority of the masters programs were offered by private and Public Research Universities-Extensive (DE), like Clark University, Salem University, University of Wisconsin, and the University of Denver.

Very few institutions offer Ph.D. programs in GIS. Though many institutions offering GIS may emphasize GIS, they offer the Ph.D. in geography, not "GIS".

Chart 8
Type of GIS Education Offered by Geography Departments



Certificate Programs

According to survey results, 41 institutions offer certificate programs. Most of the programs are in the East Coast, West Lakes States, and West Coast regions. The types of institutions offering GIS certificate programs are mostly research-I and II universities. Map 5 shows the regional distribution and type of the institutions offering

Map 5

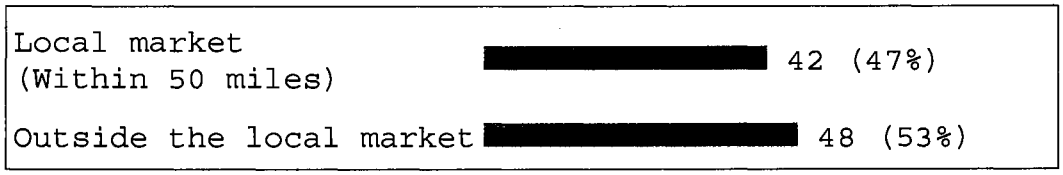
the program. Almost half of the certificate programs are offered in Research I (DE) Universities. The rest of the certificate programs are offered in research II universities, M-I colleges and some other colleges.

Service Areas of the GIS Institutions

Knowing where the graduates of GIS programs work is quite important as geography departments develop their curriculum. The question "where do GIS graduates work?" was asked in order to determine whether geography departments serve the local market or outside the local market. For this study, the local market was determined as being within 50 miles of the institution since it is a reasonable distance to travel in a short time. According to the survey results (Chart 9 and Appendix F), almost half of the institutions (47 percent) reported that their GIS graduates work in the local market.

Chart 9

The Place that GIS Graduates Work



Characteristics of the Population and GIS Market

The majority of the Baccalaureate Colleges-Liberal Arts Colleges offering GIS education are private colleges. All of them are in large cities (highly populated areas having populations of more than two million). They are mostly located in the Northeastern and East Lakes regions.

Only nine Research-Extensive (DE) institutions are located in areas having less than one million population while 20 institutions are located in areas with a population between one million and five million. All but two are public institutions. There is no Research-Intensive (DI) institution in an area with a population more than four million. Most of them are located in very low populated areas like Montana and North and South Dakota.

Nearly 15 percent of the institutions are Master Colleges (M-I) with less than one million population within a 50 mile range of the institution. Only two M-I Colleges are in highly populated area with more than 10 million people. These public colleges offer geography at the master's or bachelor's level.

Most of the institutions in an area of less than one million population offer both undergraduate and graduate GIS courses. The tables and charts show that there is no

direct relationship between population and GIS course offerings.

There is also no direct relationship between the regional population and the number of students in GIS programs. Almost all institutions having fewer than 100 GIS students have a local population in the range of one million to seven million (Chart 10).

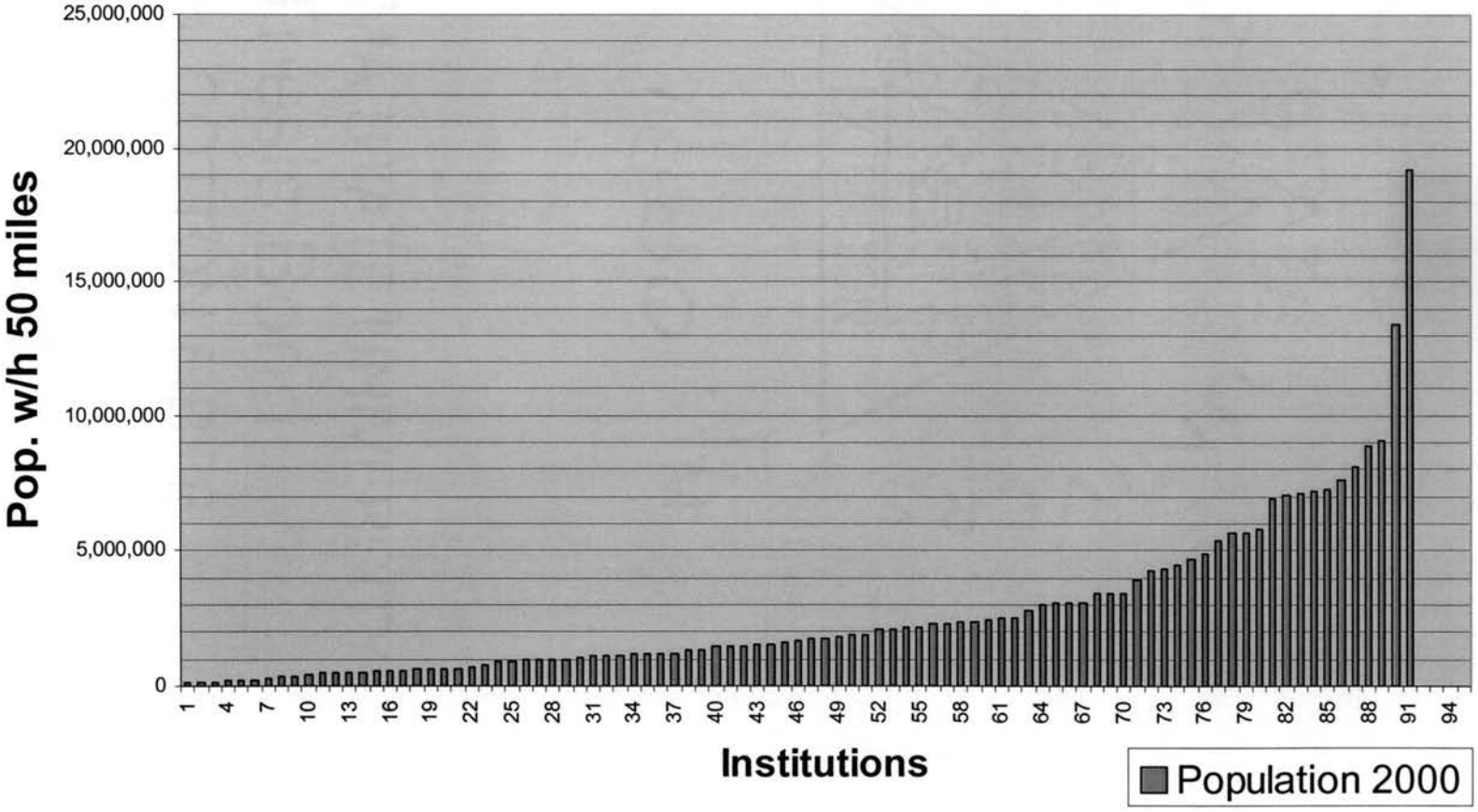
The mobility of GIS graduates also shows varying characteristics. Eight institutions in an area with less than one million population report that their graduates go to work within the local market. In addition, 27 institutions in areas with a population between two million and five million report that GIS graduates work in the local market. Only two institutions in areas of more than ten million local population report that their graduates work in the local market (California State-Long Beach and California State-San Bernardino). These two institutions are in the heart of large populations with significant GIS business opportunities and employment bases.

Nearly 20 percent of the institutions in areas of less than one million population report that GIS graduates work outside of the local market. All institutions in areas of less than five million within a 50 mile range report that their graduates go to work outside of the local market.

However, there is a tendency for institutions having lower local populations to send graduates to work outside of the local market.

Chart 10

Population Distribution within 50 Miles of Each GIS-Offering Institution



C. SUMMARY OF DESCRIPTIVE DATA ANALYSIS

A large number of predictable relationships are evident in the descriptive data presented in this chapter. These Results do not reduce the importance of analyzing such information, nor decrease the relevance of the analysis itself or of the unusual and unexpected details found in the analyses. As can be seen, the four-year institutions exercise a great deal more power in GIS education in terms of the numbers of the students and faculty and the size of the program. Regional divisions and spatial distribution of the GIS programs are also important findings from the descriptive statistics. Large universities and geography departments have a strong advantage in offering large size GIS education programs.

Chapter IV

ANALYSIS OF DATA AND HYPOTHESIS TESTING

A. DATA COMPILATION FOR HYPOTHESIS TESTING

As with the descriptive analyses presented in Chapter III, the data for the hypothesis-testing in this study were also obtained from the Census 2000, AAG catalog 2000, and the files of the survey results from the higher education institutions offering GIS education. The same basic data compiled for the analysis of the research questions was used to test the research hypotheses. The compilation of population and survey results provided the information for testing these hypotheses dealing with size and type of the institutions, type of GIS education (environmental versus socioeconomic), changes in student enrollment in geography departments, regional differences in GIS programs, effect of local population, and the demand for GIS graduates in the local market. By testing these hypotheses, it was possible to develop a more complete understanding of GIS education patterns in the United States.

As the population level and survey data were central to all hypotheses tested in this study, using inferential methods was not necessary. For clarity, however, the basic significance tests and tables are shown. These tables will allow for more precise and meaningful statements regarding

the relationships or differences found during the analyses and testing of the hypotheses.

B. RESULTS OF HYPOTHESIS TESTING

Type, Location, and Size of the Institution Offering GIS Programs

Since survey results were used to test the hypotheses, data compiled from the survey were analyzed as to how they describe the population. Thus, chi-square was run for all hypotheses to make sure all data represent the population (93 out of 237). All hypothesis tests were conducted at the 0.05 level of significance.

Hypothesis 1 stated: "Doctoral/research universities have larger GIS programs than baccalaureate and master's colleges." The basic assumption of this statement is that a large research institution (DE-DI) has more advantages in terms of the number and quality of faculty members in GIS and in support technology and fewer financial constraints. In Table 11, the results of the survey are shown as they related to the type of academic institutions and size of GIS programs. According to this information, there is a positive correlation between the types and sizes of the institutions. The majority of research universities have a large number of students in their GIS programs. The results show that 72 percent of Research I and II Universities had

more than 50 students while 27 percent had fewer than 50 students. On the other hand, only 37 percent of the master colleges had more than 50 students in their GIS programs. The chi-square results in Table 12 also support the hypothesis. Therefore, these findings support the state Hypothesis 1. These findings present evidence that most of the research universities have quite large GIS programs. Thus, it can be stated that Hypothesis 1 is true.

Table 11

The Type of GIS Offering Institutions and the Size of GIS Education

Carnegie Classification	More than 50 Students	Less than 50 Students
DE	**25**	6
DI	9	7
AC	0	1
BG	0	2
BL	0	3
M-I	13	**23**
Total	**47**	**42**

Table 12

Chi-Square Calculation Table for Type and Size of the Institutions

Question	Type	(O)	(E)	(O-E)	(O-E)2	(O-E)2/E
Yes	DE	25	16.37	8.629	74.46	4.549
Yes	DI	9	8.449	0.551	0.303	0.036
Yes	AC	0	0.528	-0.53	0.279	0.528
Yes	BG	0	1.056	-1.06	1.116	1.056
Yes	BL	0	1.584	-1.58	2.51	1.584
Yes	M-I	13	19.01	-6.01	36.13	1.901
No	DE	6	14.63	-8.63	74.46	5.09
No	DI	7	7.551	-0.55	0.303	0.04
No	AC	1	0.472	0.528	0.279	0.591
No	BG	2	0.944	1.056	1.116	1.182
No	BL	3	1.416	1.584	2.51	1.773
No	M-I	23	16.99	6.011	36.13	2.127
	N=	89	89	0.00	229.6	X2=20.46

Calculating expected frequencies: Erc = (fr)(fc)/N

Erc: expected frequency for a cell in row r and column c

fr: number of observations (frequency) in the rth row

fc: number of observations (frequency) in the cth column

N: total number of observations

Ho: There is no relationship between Carnegie Classification (CC) and Size of Programs

Hi: There is a relationship between CC and Size of programs

Calculating the degrees of freedom:

df = (r-1)(c-1) = (2-1) (6-1) = 5

if X2obs larger than X2 crit (.05, 5) do reject Ho

if X2obs smaller than X2 crit.(.05, 5) do not reject Ho

X2obs: 20.46

X2crit: 11.07

Since X2obs is significant at the 0.05 with 5df, we reject Ho and assume Hi is correct. This means that the answers on the question are related to the respondents' category (type of institutions). Therefore, we can conclude that large research universities have larger GIS programs than smaller colleges.

Level of GIS Courses

Hypothesis 2 addressed the relationship between the type of university and level of GIS courses offered. The hypothesis stated: "Most graduate programs are in research universities while undergraduate programs are in small universities." The reason for this assumption was very similar to that for Hypothesis 1. Since large universities have more opportunities (financially and academically) than smaller colleges, they attract more students.

Table 13 displays the results of the survey and shows the type of institution and level of the GIS courses offered. Table 13 shows that research universities offer dominantly both graduate and undergraduate level GIS courses (84 percent) while only 16 percent of the research universities have only undergraduate-level courses. On the other hand, almost 50 percent of the master's level colleges offer only undergraduate level GIS courses.

Table 13

The Type of GIS-Offering Institution and Level of Offered GIS Courses

Carnegie Classification	Course offered both Bach. & Graduate Level	Course offered only Bachelor level
DE	**27**	3
DI	**12**	4
AC	NA	NA
BG	1	1
BL	0	3
M-I	**18**	**16**

Since the chi-square observed value is smaller than the critical value, we do not reject the research hypothesis. Most research universities offer GIS programs at both undergraduate and graduate levels while small colleges offer only undergraduate level GIS (Table 14).

Table 14

The Level of GIS Programs Offered by Institutions (Chi-Square)

Type of University	Courses Offered (O)	Expected Proportion	Expected frequencies (E)	(O-E)	(O-E)2	(O-E)2/E
DE	27	0.416	23.712	3.288	10.81094	0.455927
DI	12	0.168	9.576	2.424	5.875776	0.613594
M-1	18	0.416	23.712	-5.712	32.62694	1.375968
N =	57	1	57	0	49.31366	X2 = 2.445489

Explanations:

Ho: There is no relationship between CC and Level of Course offering.

Hi: There is a relationship between CC and Level of Course Offering.

Expected proportion is calculated based on 214 Colleges (total population) from AAG catalog 2000 (89 DE, 89 M-1, 36 DI colleges).

Expected frequencies were calculated based on: expected proportion multiplied by n = 57

df = 2

X2 (obs.) = 2.45
X2 (crit.) (.05, 2) = 5.99

Decision Rule:
if X2 (obs.) larger than X2 (crit) reject Ho.
if X2 (obs.) smaller than X2 (crit) do not reject Ho.

Since our observed X2 is smaller than the critical value, we do not reject our hypothesis. Therefore, we can conclude that most of the large universities offer GIS

courses at both the undergraduate and graduate levels while smaller institutions offer only undergraduate level courses. Thus, this information supports Hypothesis 2.

The Type of GIS Education

Hypothesis 3 stated that there is no significant difference between the offering of socio-economic and of environmental applications. It was assumed that universities equally offer these two types of applications. The rationale for this hypothesis is that if an institution offers one type, it is easy to offer the other as well because often the same facility and faculty can teach both types of GIS applications. The hypothesis stated: "Socio economic and Environmental GIS applications are offered equally in the GIS programs." Table 15 shows the distribution of the types of GIS education. The information in the table shows that most research universities and master colleges offer both programs together. According to the analysis, over 82 percent of geography departments offer both socio-economic and environmental applications. Only 15 percent of the institutions offer environmental applications alone. Thus, if more than three-fourths of the institutions offer both types of GIS education, it may be concluded that the findings support Hypothesis 3. Nonetheless, nearly 15 percent of the institutions offer

only environmental applications while only one institution reported offering only socio-economic applications. This may contribute some doubts for our conclusion. However, the observed value in the chi-square estimation is very close to the expected value, which validates our hypothesis stating that "socio economic and environmental GIS applications are offered equally in all types of GIS programs" (Table 16).

Table 15

The Type of GIS Offering Institutions and Types of GIS Education Offered by Institution

Carnegie Classification	Socio-economic Applications	Environmental Applications	Both
DE	1	6	**40**
DI	0	0	0
AC	0	0	0
BG	0	1	4
BL	0	0	0
M-I	0	7	**27**
Total	**1**	**14**	**71**

Table 16

The Type of GIS Applications at Different Types of Institutions (Chi-Square Distribution)

Institutions	Both (Socio/Envi.) GIS (O)	Expected Proportion	Expected frequencies (E)	(O-E)	(O-E)2	(O-E)2/E
DE	40	0.48	34.36	5.63	31.76	0.92
M-1	27	0.48	34.36	-7.36	54.22	1.57
BG	4	0.03	2.27	1.72	2.98	1.31
N =	71	1.00	71	0.00	88.97	X2 = 3.82

Explanations:

Ho: There is no relationship between type of institution (CC) and program offerings (Socioeconomic/Natural Resource).

Hi: There is a relationship between CC and program offering.

Expected Proportion is based on 184 Colleges (population from AAG Catalog 2000). (89 DE, 89 M-I, and 6 BG colleges) Expected frequencies = n X expected proportion.

df = 2

X2 (obs.) = 3.82; X2 (crit.) (.05, 2) = 5.99

Decision rule:
Reject Ho if observed value is higher than critical value.

Since the observed X2 value is not significant at the 0.05 level with 2df, we accept Ho. It can be concluded that there is no direct relation between types of GIS offering and the institutions. It is assumed that when institutions offer GIS education, they offer both Raster and Vector based GIS.

The Effect of GIS on Enrollment in Geography Departments

In order to understand whether offering GIS education causes an increase in enrollment in geography departments, Hypothesis 4 was tested. The Hypothesis stated: "After offering GIS courses, the enrollments of an academic department increase." The logic behind this statement was that GIS creates a new job market since it uses new technology and provides specific job training to individuals. It is thought that these effects may pull students to geography departments. According to survey results (Table 17), only 25 percent of institutions think that GIS programs contributed a significant increase to their student enrollment while only five percent of geography departments think their GIS program did not pull any extra students to the department. Over all, 94 percent of the institutions think that GIS has affected their enrollments. The finding of chi-square analysis also supports the premise of the statement made in Hypothesis 4 that GIS education has had a positive effect on enrollment in geography departments (Table 18).

Table 17

Changes to Enrollment in Geography Departments after Offering GIS Education

Large Increase (%)	Small increase (%)	No change (%)
25	69	5

Table 18

Enrollment Increase at Geography Departments after Offering GIS Courses (Chi-Square)

	(O)	Expected Proportion	(E)	(O-E)	(O-E)2	(O-E)2/E
Large Increase	25	0.33	32.67	-7.67	58.82	1.80
Small Increase	69	0.34	33.66	35.34	1248.92	37.10
No Change	5	0.33	32.67	-27.7	765.62	23.43
N =	99	1	99	0	2073.37	X2=62.33

Explanations:

Ho: There is no relationship between GIS Offerings and Enrollment Changes

Hi: There is a relationship between GIS Offerings and Enrollment Changes.

Expected Proportion is based on 237 Colleges (our population from AAG Catalog 2000).

Expected frequencies = n X expected proportion

df = 1

X2 (obs.) = 62.33
X2 (crit.) (.05, 2) = 5.99

Decision rule:

If X2obs. Value is larger than X2crit. Value, reject Ho.

If X2obs. Value is less than X2crit. Value, do not reject Ho.

Since the X2 observed value is 62.33, which is significant at the 0.05 level with 2df., we reject Ho. Thus, it can be concluded that there is a relationship between GIS offering and enrollment changes.

Distance Education in GIS

Hypothesis 5 stated: "Distance GIS education has been offered mostly by a few large research universities since they have enough support personnel and facilities." Distance education is becoming more common with the help of advanced technology. Tables 19 and 20 demonstrate that only five institutions (6 percent) offer distance GIS education while 88 institutions (94 percent) do not offer these courses. One of the five geography departments offering distance education in GIS is a private institution (University of Denver, Colorado). All of these institutions are Doctoral/Research Universities-Extensive, except for the California University of Pennsylvania. All of these institutions also offer geography at the master's and doctorate level. Therefore, statically, the result does not support Hypothesis 5 that institutions offering distance GIS education are large universities and the number of

institutions is few (Table 21). However, these results must be taken with some caution, as only five institutions are represented, and the results from such a small sample can, at best, be considered tenuous.

Table 19

Distance GIS Education

Institutions offering Distance GIS education	Institutions not offering GIS Education
5	88

Table 20

Institutions Offering Distance GIS Education

Name	Degree	Type of Institution	Control
University of Denver	D	Doctoral/Research Universities–Extensive	Private, not for-profit
Utah State University	M	Doctoral/Research Universities–Extensive	Public
University of California, Santa Barbara	D	Doctoral/Research Universities–Extensive	Public
Oregon State University	D	Doctoral/Research Universities–Extensive	Public
California University of Pennsylvania	M	Master's Colleges and Universities I	Public

Table 21

Institutions offering Distance Education in GIS (Chi-Square)

	O	Expected Proportion	E	(O-E)	(O-E)2	(O-E)2/E
DE	3	0.48	2.4	0.6	0.36	0.15
M-1	2	0.48	2.4	-0.4	0.16	0.06
BG	0	0.04	0.2	-0.2	0.04	0.2
	5	1.00	5	0	0.56	X2 = 0.41

Explanations:

Ho: There is no relationship between CC and GIS Distance Education Offerings.

Hi: There is a relationship between CC and GIS Distance Education Offerings.

Expected Proportion is based on 237 Colleges (population from AAG Catalog 2000). Expected frequencies = n X expected proportion

df = 2

X2 (obs.) = 0.41
X2 (crit.) (.05, 2) = 5.99

Decision rule:
Reject Ho if observed value is higher than critical value.

Since the X2 observed value is 0.41, which is not significant at the 0.05 level with 2df, we accept Ho. Thus, it can be concluded that there is no relationship between Carnegie Classification (CC) and distance GIS education. In addition, it is clear that the number of samples is very low, which may affect the chi-square results.

Regional Differences in GIS Education

Hypothesis 6 dealt with the relationship between rural/urban types and distribution of GIS education. If a GIS institution is located in a rural area, the emphasis is probably different from the emphasis in a GIS institution located in a large city. The hypothesis stated: "An institution offering GIS designs its programs for the demand of the local market. Most rural institutions offer agricultural applications while the urban institutions offer more theory-oriented applications. In addition, different types of institutions offering GIS education show an even distribution in each region in the US." Appendix G shows the institutions offering GIS and their population within a 50-mile range. More than 66 percent of the institutions offer academic theory and application GIS courses, which means that no matter where they are located (sparsely or highly populated), they will offer fundamentals of GIS. According to the survey and chi-square test results (Table 22), there is no direct relationship between the location of the institutions and the type of GIS education. Therefore, the hypothesis "An institution offering GIS designs its programs for the demand of the local market" cannot be supported. In addition, the

regional distribution of the type of institutions was tested.

Table 22

Chi-Square Distribution between Location of GIS Institutions and the Type of GIS Courses Offered

		O	E	(O-E)	(O-E)2	(O-E)2/E
Yes	Vector	5	4.71	0.29	0.08	0.06
Yes	Raster	12	13.22	-1.22	1.48	0.11
Yes	Both	53	52.13	0.87	0.75	0.01
No	Vector	1	1.33	-0.33	0.10	0.08
No	Raster	5	3.73	1.27	1.61	0.43
No	Both	14	14.88	-0.88	0.77	0.05
	N =	90	90	0	4.82	X2 = 0.76

Explanations:

Total Population: 237
Total institutions in MSA: 180
Total Institutions out of MSA: 57

Samples: (survey results)
Total Institutions in MSA: 70
Total Institutions out of MSA: 20
Total Sample: 90

Expected Value: Row Total*Column Total/Sum Total

Ho: There is no relationship between locations of institutions (Rural/Urban) and type of GIS courses. (Vector/Raster).

Hi: There is a relationship between location of institutions (Rural/Urban) and type of GIS courses (Vector/Raster).

Calculating the degrees of freedom:

df = (r-1)(c-1) = (2-1) (3-1) = 2

If X2obs larger than X2 crit (.05, 2) reject Ho.
If X2obs smaller than X2 crit.(.05, 2) do not reject Ho

X2obs: 0.76
X2crit: 5.99

Since the observed X2 equals 0.76, which is not significant at the 0.05 Level with 2df, we accept our research hypothesis (Ho). It can be concluded that there is no relationship between location of the GIS institutions (Rural/Urban) and type of GIS education.

According to the chi-square results in Table 23, the distribution of the GIS-offering institutions by each region is not significantly different from the distribution of the institutions by regions as a whole. Thus, the sample represents all institutions by region.

Table 23
Chi-Square for Types of Institutions and Their Regional Distributions

Category	Observed freq. (O)	Expected Proportion	(E)	(O-E)	(O-E)2	(O-E)2/E
Pacific Coast Division	12	0.16	14.56	-2.56	6.55	0.45
Great Plains-Rocky Mountains	10	0.08	7.28	2.72	7.39	1.01
Southwest	4	0.07	6.37	-2.37	5.61	0.88
West Lakes	13	0.18	16.38	-3.38	11.42	0.69
Southeast	22	0.18	16.38	5.62	31.58	1.92
Middle Atlantic	3	0.04	3.64	-0.64	0.40	0.11
Middle States	12	0.14	12.74	-0.74	0.54	0.04
East Lakes	11	0.07	6.37	4.63	21.43	3.36
New England-St. Lawrence Valley	4	0.08	7.28	-3.28	10.75	1.47
N =	91	1.00	91	0.00	95.73	X2=9.97

Explanations:

Expected Proportion is based on 237 Colleges (the population from AAG Catalog 2000).

Expected frequencies = n * expected proportion

Ho: There is no relationship between CC and their regional distributions.

Hi: There is a relationship between CC and their regional distributions.

df = 8

X2 (obs.) = 9.97
X2 (crit.) (.05, 8) = 15.50

Decision rule:

Reject hypothesis if observed value is higher than critical value.

We do not reject the research hypothesis since the critical value is higher than the observed value. Thus, it can be concluded there is no relationship between types of institutions (CC) and their regional distributions.

GIS Education and the Job Market

Hypothesis 7 stated that when the GIS students graduate, they work mostly in the local market area. The logic behind this hypothesis was that GIS institutions designed their GIS program for the needs of the local market. If institutions offer programs the local businesses and institutions need, GIS graduates, then, should work in the local area. The hypothesis stated: "There is a direct relationship between local population/market and GIS education. Most graduates serve the local market since the institution designed its program for the local market." According to the survey results (Chart 9), almost half of the institutions reported that their GIS graduates work in the local market (47 percent) while the other half of institutions reported they work outside of the local market. The survey results showed that there is no relationship between the GIS curriculum programs and working in the local market. Some of the large institutions located in large cities on the west coast stated that their graduates work in the local market. However, these

institutions are located at the center of high technology demand such as the University of California, Los Angeles, Santa Barbara, and San Bernardino. Thus, the finding did not support hypothesis 7, that most GIS graduates work in the local market since the institutions design their programs for the need of the local market.

Table 24

Where GIS Graduates Work When They Finish Their Programs (Chi-Square)

	(O)	Expected Proportion	(E)	(O-E)	(O-E)2	(O-E)2/E
In the Local Market	42	0.25	22.5	19.5	380.25	16.9
Outside the Local Market	48	0.75	67.5	-19.5	380.25	5.63
N =	90	1.00	90	0.00	760.5	X2=22.53

Explanations:

Total Population: 237
Total institutions in MSA: 180
Total institutions out MSA: 57

Ho: There is no relationship between location of school and work place.

Hi: There is a relationship between location of school and work place.

Expected Proportion is based on 237 Colleges (population from AAG Catalog 2000).

Expected Proportion Calculation: 57(180)*100/237

Expected frequencies = n X expected proportion

df = 1

X2 (obs.) = 22.53
X2 (crit.) (.05, 1) = 3.84

Decision rule:
Reject hypothesis if the observed value is higher than the critical value.

Since the X2 observed value is 22.53, which is significant at the 0.05 level with 1df., we reject Ho. Thus, it can be concluded that there is no relationship between school location and working place. Thus, we reject our research hypothesis stating that there is a relationship between school location and working place since the critical value is higher than the observed value.

C. SUMMARY OF HYPOTHESES TESTING

Supported hypotheses

Hypotheses 1, 2, 3, 4, and 5 shown below, were supported:

H1. Doctoral/research universities have larger GIS programs than baccalaureate and master's colleges.

H2. Most graduate programs are in research universities while undergraduate programs are in small universities.

H3. Socio economic and Environmental GIS applications are offered equally in the GIS programs.

H4. After offering GIS courses, the enrollments of an academic department increase.

H5. Distance GIS education has been offered mostly by large research universities since they have enough support personnel and facilities. However, these results must be taken with some caution, as only five institutions are represented, and the results from such a small sample can, at best, be considered tenuous.

Non-Supported Hypotheses

Hypotheses 6 and 7, shown below, were not supported:

H6. An institution offering GIS designs its programs for the demand of the local market. Most rural institutions offer agricultural applications while the urban institutions offer more theory-oriented applications.

H7. There is a direct relationship between local population/market and GIS education. Most graduates serve the local market since the institution designed its program for the local market.

Summary

Overall, the results of the study provide information regarding the characteristics of the institutions offering GIS education and GIS programs. The type of geography departments and the Carnegie Classification of the institutions provide useful indications for analyzing the characteristics of GIS education at the institutions. It was observed that the location and the population of the GIS institutions did not play a big role in GIS education. The size, type, and enrollment of GIS programs were predicted. While these variations were predicted, the verification of these hypotheses provides useful information in analyzing the spatial distribution of GIS programs, including GIS certificate programs. The results

of the study also provide a strong foundation for further study into the curriculum for certificate programs and GIS certification programs.

Chapter V

DISCUSSION, SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

A. INTRODUCTION

The principal objectives of this study were to examine GIS education programs (in terms of their size, type, service area, relationship between institutions, and spatial distributions) in public and private higher education institutions in the United States. This study brought to the forefront valuable information regarding the GIS program within geography department and the institution's character. Researchers and some policy makers, especially in geography departments or in any higher education institution, may find this information useful in determining future development in GIS education and technology.

For this research, different databases were compiled using the Carnegie Classification of Institutions of Higher Education database, 2000 Census for all counties in the US, and a survey of higher education institutions offering GIS education at any level. The Carnegie Foundation has been classifying higher education institutions since the early 1970s and updating the classification regularly. For this research, the 2000 edition of the classification of the institutions of higher education was used to obtain

information on the targeted institutions. The initial data file of the Carnegie Classification covered all public and private higher education institutions in the US. These records provided information on the campus, location, control, and type of institution. Then, individual records were compiled into new databases in order to analyze spatial and regional distributions and serving area, and to identify the type of institution to see differences between institutions offering GIS education.

B. DISCUSSION AND SUMMARY OF THE FINDINGS

Descriptive Research Questions

A majority of the GIS programs were offered in large research universities (DE & DI) along with masters institutions (M-I). Most of these programs were located in the West Lakes, Southeast, New England, and Pacific Coast regions. GIS programs were hosted mostly by geography departments that commonly offer masters and doctoral degrees. Forty percent of small geography departments (having only undergraduate courses) offer GIS courses.

Aangeenbrug (1992) and Morgan (1986, 1987, 1992, & 1993) explained that GIS education has been growing in the United States since the early 1980s. In 1984, only 23 geography departments had faculty members specializing in GIS. By 1991, 137 programs listed GIS among their

specialties. In the early 1990s, few academic departments could afford the large expenditures necessary to acquire software, hardware, and the staff to develop a GIS facility. However this situation has changed with the inexpensive and powerful microcomputers and relatively low cost GIS software. Thus, more colleges and universities are offering GIS courses than ever before.

Morgan's 1993 survey showed that only 54% of geography departments offered GIS courses. However, the current study shows that almost all geography departments offer GIS courses. In 1993, the most important problems departments reported were the lack of staff who could teach GIS and the lack of interest of students and others in the program. In addition, early GIS-offering institutions lacked GIS-related textbooks. According to this study, these problems no longer exist.

Aangeenbrug (1992) reported that most universities did not have the capability to support GIS course work and very few were able to support a large multiple curriculum in GIS. According to this research, almost all four year universities having geography departments offer some form of GIS. Dahlberg (1983) stated that basic academic theory and basic courses were offered by many colleges and universities while most of the advanced courses were

offered at Research Extensive (DE) and Research Intensive (DI) universities, which is supported by the finding of this study.

Morgan (1993) stated that along with geography departments, many different academic departments offer GIS courses including agronomy, forestry, landscape architecture, civil engineering, and urban and regional planning. Today, most GIS programs are hosted by geography departments and the others' share is very low.

Goodchild and Kemp (1992) wrote that GIS courses have become a common component of undergraduate programs. According to this study, GIS courses are a permanent part of the geography curriculum not only at the undergraduate level but also at the graduate level in geography education. Obermeyer (1997) argued that GIS education greatly benefits the individuals. This idea was supported by the finding of this study that when geography departments offer GIS, their enrollment increases as well. When individuals receive GIS education, they have the opportunity to earn a higher salary, to improve their performance, and to find good jobs.

Most geography departments are located in publicly controlled higher education institutions, as are GIS programs. Most of the private higher education institutions

offering GIS education are located in the New England, Middle States, and West Lakes regions.

The regional distribution of GIS programs also shows different characteristics. The geographical size of the region and the population show a pronounced effect on the number of institutions in each region. Most of the geography programs offering bachelor's level programs are located in the West Lakes, Southeast, and Middle States regions while master's and doctoral level institutions are in the Pacific Coast and Southeast divisions.

The size of the GIS program also changes from institution to institution. Almost half of the institutions had fewer than 50 students while only 23 percent of the programs had more than 100 students in a year.

According to the survey results, most institutions' GIS programs attracted students. In addition, distance education in GIS is still premature and few programs offer such courses. One of the findings is that almost all institutions were offering both socioeconomic and environmental applications in their programs.

Robinson (1991) stated that there is a large market for certificate programs and the universities and colleges were not capturing as much as of the market share as they could. This research proves that many institutions have

eagerly started GIS certificate programs since that time. The distribution of GIS certificate programs showed similarities within GIS-offering institutions. Certificate programs have some advantages over universities and colleges in attracting new customers (students and business contractors).

While a GIS certificate has a large number of applications (41 institutions), Certification in GIS is not common (only three institutions). Huxhold (1995) stated that there is no licensing or certification of GIS practitioners and professionals in any specific college and university. According to this research, even though a few universities want to be involved in developing certification programs, it has not been accepted by the GIS community nationwide. ASPRS (Certified Mapping Scientist, IGS /LIS) and ISO (International Organization for Standardization) have GIS certification programs (Obermeyer (n.d.). Even though degree programs in GIS had been offered in Europe for more than a decade, such programs started in the US in the late 1980s (Gittings at al. 1993).

GIS distance education has been offered in Europe since the early 1990s. Even though distance learning in GIS is becoming popular in the US, few universities offer it. The main reason is that most institutions do not have

enough hardware, financial, and technological support (Strobl 1995).

GIS graduates work equally in the local market and outside of the local market. However, some programs send their graduates outside of the local market while some institutions' graduates work within the local market. Institutions that are located in large populated areas send their graduates to work in the local market. There is also no direct relationship between the regional population and the number of students in GIS programs.

Hypothesis Testing

The differences and relationships between various aspects of GIS education were analyzed using chi-square and correlations. The data in this study represent only GIS programs in geography departments. The following significant relationships or differences were found during the study:

1. Doctoral/research universities (including DE & DI) had more and larger GIS programs than did baccalaureate and master's colleges.
2. Most graduate programs were in research universities while undergraduate programs were in small size universities (master colleges).

3. Socio economic and environmental GIS applications were offered equally in GIS programs.
4. After offering GIS courses, the enrollments of most academic departments increased.
5. Distance GIS education has been offered mostly by large research universities since they have enough support personnel and facilities.
6. Institutions usually designed GIS programs not specifically for local needs but to teach the fundamentals of GIS. Institutions located in rural areas or in urban areas offered similar curriculum programs in GIS.

The following items were found to have weaker relationships. The overall lack of strength of these relationships led either to only a partial support for or to the failure of the associated research hypotheses.

A weak positive relationship seems to exist between the local population/market and GIS education. Most graduates serve the local market in large populated areas like Los Angeles, San Diego, and San Francisco in California while in less populated areas GIS graduates either worked in the local market or left to work outside of the local market.

C. CONCLUSIONS

The results of the analyses and tests performed during this study lead to the following conclusions:

1. The spatial distribution of GIS education shows an even distribution nation wide. The major effects on the distribution are the size and the population of the divisions. As expected, most of the highly populated regions offered more GIS programs than did less populated regions. The East and West Coast, specifically the New England and Middle States, the Eastern and the Lakes regions have the majority of GIS-offering institutions. Most of the GIS programs are at the graduate level though undergraduate GIS education is also relatively high (40 percent). Almost all GIS programs offer GIS education for both socioeconomic and environmental applications.
2. Though GIS education programs show similarities in curriculum between institutions, the types of the institutions show different characteristics. Most of the research-extensive, research-intensive universities and master colleges offer GIS education while most of the community colleges and other two-year colleges did not include GIS

education. Most of the research-extensive institutions have larger GIS programs in terms of number of students and the types of courses offered in GIS-related subjects.

3. The lack of strong relationships between GIS graduates and their working areas (local or outside the local market) makes it difficult to predict the relationship between the market and GIS education relations.
4. Most of the GIS-offering institutions are public higher education institutions.

D. RECOMMENDATIONS

Based on the findings and conclusions of the study, the following recommendations are made:

1. Further research applications and refinements on GIS education at the college level should be completed in order to produce a predictive GIS education in different levels of academic fields. The refinements should include the addition of factors such as curriculum details, GIS facilities, availability of GIS software, and availability of GIS faculty and support people.
2. Further analysis into local markets and GIS education programs should be made to clarify the

role of the demand from local business, governmental agencies, and other private institutions on the design of local-area GIS curricula.

3. In this study, only four-year higher education institutions were included. Further studies should include all two-year colleges, and private and public institutes that offer GIS education, and other GIS institutions including vendors. This would allow researchers and administrators to better comprehend GIS education trends in the United States.
4. This study did not focus on GIS-degree programs. Further studies should examine GIS education in detail to include degree programs in Geographic Information Science, including certificate programs, and bachelor's, master's, and Ph.D.s in GIS.

Though some studies have been done, there are many gaps to fill in the analysis of GIS education. This study has helped to close at least some part of the gap. A new survey needs to be designed to provide new data. In addition, more detailed information about distance GIS education, including certificate programs and degrees, is

essential in order to keep up with current trends in GIS education.

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APPENDICES

APPENDIX A

GIS Education Survey

University GIS Representative:

This survey was designed by Halil I. Tas, under the supervision of Drs. Allen Finchum, and Dale Lightfoot of the Department of Geography at Oklahoma State University, in Stillwater, Oklahoma. This survey is the first step of a project to analyze GIS Education at institutions of higher education in the United States. Your assistance in completing this survey is greatly appreciated, and by providing the information requested below, you are helping to ensure that the issues identified are truly representative of all institutions providing GIS education. The results of this survey will be returned to you if you desire.

If you have any questions please contact Halil I. Tas (phone: 918 808 9524, fax: 918 834 3352, or e-mail: thalil@okstate.edu).

Please select the response that corresponds to your answer, and be aware that there are no right or wrong answers; rather, we are interested in your opinion or position on each issue or question.
Thanks again for your assistance and response.

1) Your Name: _____

2) What is your position? _____

3) What institute do you represent? _____

4) What is your email address? _____

5) Have you offered any GIS courses in the last 2 years?

- No
- Yes

6) At what level do you offer GIS courses?

- Undergraduate
- Graduate
- Both

7) What types of GIS do you emphasize?

- Socioeconomic Applications
- Environmental Applications
- Both

8) Approximately how many students do you have in your GIS program? (The program means here any student who takes GIS related courses from your department)

- 0-50
- 50-100
- 100-150
- More than 150

9) How many GIS courses did you offer during Spring, Summer, and Fall 2000?

- 1-3
- 4-6
- 7-9
- More than 9

10) How does GIS affect your geography student enrollment?

- Large Increase
- Small Increase
- No Change

11) What types of GIS education do you offer?

- Academic theory and application GIS courses only
- Certificate program
- Certification program
- Bachelor in GIS
- Masters in GIS
- Ph.D. in GIS

12) Does your program offer distance learning in GIS?

- Yes
- No

13) When your students finish GIS programs, they pursue employment in:

- Local market (within 50 miles)
- Outside the local market

APPENDIX B

Sample Data from Census 2000

Source: U.S. Census Bureau, Census 2000 Redistricting Data (P.L. 94-171) Summary File and 1990 Census.
Internet Release date: April 2, 2001

Rank (of 3,141 Counties)	State and County FIPS codes	County Name	State	Census population April 1, 2000
1	06037	Los Angeles County	CA	9,519,338
2	17031	Cook County	IL	5,376,741
3	48201	Harris County	TX	3,400,578
4	04013	Maricopa County	AZ	3,072,149
5	06059	Orange County	CA	2,846,289
6	06073	San Diego County	CA	2,813,833
7	36047	Kings County	NY	2,465,326
8	12086	Miami-Dade County	FL	2,253,362
9	36081	Queens County	NY	2,229,379
10	48113	Dallas County	TX	2,218,899
11	26163	Wayne County	MI	2,061,162
12	53033	King County	WA	1,737,034
13	06071	San Bernardino County	CA	1,709,434
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
3126	31091	Hooker County	NE	783
3127	31113	Logan County	NE	774
3128	38087	Slope County	ND	767
3129	31075	Grant County	NE	747
3130	48033	Borden County	TX	729
3131	31171	Thomas County	NE	729
3132	31115	Loup County	NE	712
3133	31009	Blaine County	NE	583
3134	08111	San Juan County	CO	558
3135	31117	McPherson County	NE	533
3136	30069	Petroleum County	MT	493
3137	31005	Arthur County	NE	444
3138	48261	Kennedy County	TX	414
3139	48269	King County	TX	356
3140	15005	Kalawao County	HI	147
3141	48301	Loving County	TX	67

APPENDIX C

Carnegie Classification of Universities Hosting Geography Departments and GIS Programs

Name of the Institution	State Code	State	Regional Divisions	Control
Ohio Wesleyan University	OH	Ohio	East Lakes	Private, not for-profit
Michigan State University	MI	Michigan	East Lakes	Public
Kent State University	OH	Ohio	East Lakes	Public
The Ohio State University	OH	Ohio	East Lakes	Public
University of Cincinnati	OH	Ohio	East Lakes	Public
Wayne State University	MI	Michigan	East Lakes	Public
Western Michigan State University	MI	Michigan	East Lakes	Public
Ohio University	OH	Ohio	East Lakes	Public
University of Toledo	OH	Ohio	East Lakes	Public
Central Michigan University	MI	Michigan	East Lakes	Public
Bowling Green State University	OH	Ohio	East Lakes	Public
Wright State University	OH	Ohio	East Lakes	Public
Miami University	OH	Ohio	East Lakes	Public
University of Akron	OH	Ohio	East Lakes	Public
Northern Michigan University	MI	Michigan	East Lakes	Public
Youngstown State University	OH	Ohio	East Lakes	Public
Eastern Michigan University	MI	Michigan	East Lakes	Public
Metropolitan State College of Denver	CO	Colorado	Great Plains-Rocky Mountains	Public
University of Denver	CO	Colorado	Great Plains-Rocky Mountains	Private, not for-profit
University of Colorado Boulder	CO	Colorado	Great Plains-Rocky Mountains	Public
Kansas State University	KS	Kansas	Great Plains-Rocky Mountains	Public
University of Kansas	KS	Kansas	Great Plains-Rocky Mountains	Public
University of Nebraska at Lincoln	NE	Nebraska	Great Plains-Rocky Mountains	Public
University of Utah	UT	Utah	Great Plains-Rocky Mountains	Public
Brigham Young University	UT	Utah	Great Plains-Rocky Mountains	Private, not for-profit

Utah State University	UT	Utah	Great Plains-Rocky Mountains	Public
University of Northern Colorado	CO	Colorado	Great Plains-Rocky Mountains	Public
Montana State University	MT	Montana	Great Plains-Rocky Mountains	Public
University of Montana	MT	Montana	Great Plains-Rocky Mountains	Public
University of North Dakota	ND	North Dakota	Great Plains-Rocky Mountains	Public
South Dakota State University	SD	South Dakota	Great Plains-Rocky Mountains	Public
University of Nebraska at Kearney	NE	Nebraska	Great Plains-Rocky Mountains	Public
Un. of Colorado at Colorado Spring	CO	Colorado	Great Plains-Rocky Mountains	Public
University of Nebraska at Omaha	NE	Nebraska	Great Plains-Rocky Mountains	Public
Weber State University	UT	Utah	Great Plains-Rocky Mountains	Public
United States Air Force Academy	CO	Colorado	Great Plains-Rocky Mountains	Public
American University	DC	District of Columbia	Middle Atlantic	Private, not for-profit
Johns Hopkins University	MD	Maryland	Middle Atlantic	Private, not for-profit
University of Delaware	DE	Delaware	Middle Atlantic	Public
George Washington University	DC	District of Columbia	Middle Atlantic	Private, not for-profit
Un. of Maryland Baltimore County	MD	Maryland	Middle Atlantic	Public
University of the District of Columbia	DC	District of Columbia	Middle Atlantic	Public
Frostburg State University	MD	Maryland	Middle Atlantic	Public
Salisbury State University	MD	Maryland	Middle Atlantic	Public
University of Maryland College Park	MD	Maryland	Middle Atlantic	Public
Towson State University	MD	Maryland	Middle Atlantic	Public
University of Pittsburgh at Johnstown	PA	Pennsylvania	Middle States	Public
Colgate University	NY	New York	Middle States	Private, not for-profit
St Lawrence University	NY	New York	Middle States	Private, not for-profit
Vassar College	NY	New York	Middle States	Private, not for-profit
Bicknell University	PA	Pennsylvania	Middle States	Private, not for-profit
Syracuse University	NY	New York	Middle States	Private, not for-profit
Rutgers University	NJ	New Jersey	Middle States	Public
State University Of NY at Buffalo	NY	New York	Middle States	Public
Pennsylvania State University	PA	Pennsylvania	Middle States	Public
State University of New York at Albany	NY	New York	Middle States	Public
State Un. of NY at Binghamton	NY	New York	Middle States	Public

Temple University	PA	Pennsylvania	Middle States	Public
Hofstra University	NY	New York	Middle States	Private, not for-profit
Indiana University of Pennsylvania	PA	Pennsylvania	Middle States	Public
Rowan University	NJ	New Jersey	Middle States	Public
State University of NY at New Paltz	NY	New York	Middle States	Public
Montclair State University	NJ	New Jersey	Middle States	Public
Buffalo State College	NY	New York	Middle States	Public
California University of Pennsylvania	PA	Pennsylvania	Middle States	Public
State Un. of NY College at Cortland	NY	New York	Middle States	Public
State Un. of NY College at Geneseo	NY	New York	Middle States	Public
State Un. of NY College at Oneonta	NY	New York	Middle States	Public
Bloomsburg University	PA	Pennsylvania	Middle States	Public
Clarion University of Pennsylvania	PA	Pennsylvania	Middle States	Public
Edinboro University	PA	Pennsylvania	Middle States	Public
Kutztown University of Pennsylvania	PA	Pennsylvania	Middle States	Public
Mansfield University of Pennsylvania	PA	Pennsylvania	Middle States	Public
Millersville University	PA	Pennsylvania	Middle States	Public
City Un. of NY Hunter College (CUNY)	NY	New York	Middle States	Public
Shippensburg Un. of Pennsylvania	PA	Pennsylvania	Middle States	Public
West Chester University	PA	Pennsylvania	Middle States	Public
United States Military Academy	NY	New York	Middle States	Public
University of Maine	ME	Maine	New England-St. Lawrence Valley	Public
Mount Holyoke College	MA	Massachusetts	New England-St. Lawrence Valley	Private, not for-profit
Middlebury College	VT	Vermont	New England-St. Lawrence Valley	Private, not for-profit
University of New Hampshire	NH	New Hampshire	New England-St. Lawrence Valley	Public
Boston University	MA	Massachusetts	New England-St. Lawrence Valley	Private, not for-profit
University of Massachusetts-Boston	MA	Massachusetts	New England-St. Lawrence Valley	Public
University of Massachusetts-Amherst	MA	Massachusetts	New England-St. Lawrence Valley	Public
University of Connecticut	CT	Connecticut	New England-St. Lawrence Valley	Public
University of Vermont	VT	Vermont	New England-St. Lawrence Valley	Public
Dartmouth College	NH	New Hampshire	New England-St. Lawrence Valley	Private, not for-profit
Clark University	MA	Massachusetts	New England-St. Lawrence Valley	Private, not for-profit

Southern Connecticut State University	CT	Connecticut	New England-St. Lawrence Valley	Public
University of Southern Maine	ME	Maine	New England-St. Lawrence Valley	Public
Plymouth State College	NH	New Hampshire	New England-St. Lawrence Valley	Public
Rhode Island College	RI	Rhode Island	New England-St. Lawrence Valley	Public
Central Connecticut State University	CT	Connecticut	New England-St. Lawrence Valley	Public
Bridgewater State College	MA	Massachusetts	New England-St. Lawrence Valley	Public
Salem State College	MA	Massachusetts	New England-St. Lawrence Valley	Public
Keene State College	NH	New Hampshire	New England-St. Lawrence Valley	Public
College of Alameda	CA	California	Pacific Coast	Public
University of Southern California	CA	California	Pacific Coast	Private, not for-profit
Arizona State University	AZ	Arizona	Pacific Coast	Public
University of Arizona	AZ	Arizona	Pacific Coast	Public
University of California at Berkeley	CA	California	Pacific Coast	Public
University of California at Davis	CA	California	Pacific Coast	Public
University of California	CA	California	Pacific Coast	Public
Un. of California at Santa Barbara	CA	California	Pacific Coast	Public
University of Hawaii at Mania	HI	Hawaii	Pacific Coast	Public
University of Idaho	ID	Idaho	Pacific Coast	Public
Oregon State University	OR	Oregon	Pacific Coast	Public
University of Oregon	OR	Oregon	Pacific Coast	Public
University of Washington	WA	Washington	Pacific Coast	Public
University of Nevada	NV	Nevada	Pacific Coast	Public
University of California at Los Angeles	CA	California	Pacific Coast	Public
University of Alaska	AK	Alaska	Pacific Coast	Public
Portland State University	OR	Oregon	Pacific Coast	Public
Northern Arizona University	AZ	Arizona	Pacific Coast	Public
San Diego State University	CA	California	Pacific Coast	Public
California State Polytechnic University	CA	California	Pacific Coast	Public
California State Un. at Sacramento	CA	California	Pacific Coast	Public
Humboldt State University	CA	California	Pacific Coast	Public
Sonoma State University	CA	California	Pacific Coast	Public
Western Oregon State University	OR	Oregon	Pacific Coast	Public

Eastern Washington University	WA	Washington	Pacific Coast	Public
California State University at Chico	CA	California	Pacific Coast	Public
California State University at Hayward	CA	California	Pacific Coast	Public
California State Un. at Los Angeles	CA	California	Pacific Coast	Public
California State Un. at North Ridge	CA	California	Pacific Coast	Public
California State Un. at San Bernardino	CA	California	Pacific Coast	Public
California State University at Fresno	CA	California	Pacific Coast	Public
California State University at Fullerton	CA	California	Pacific Coast	Public
California State Un. at Long Beach	CA	California	Pacific Coast	Public
San Francisco State University Multidisciplinary GIS Center	CA	California	Pacific Coast	Public
San Jose State University	CA	California	Pacific Coast	Public
Central Washington University	WA	Washington	Pacific Coast	Public
Western Washington University	WA	Washington	Pacific Coast	Public
Concord College	WV	West Virginia	Southeast	Public
Emory and Henry College	VA	Virginia	Southeast	Private, not for-profit
Mary Washington College	VA	Virginia	Southeast	Public
Auburn University	AL	Alabama	Southeast	Public
University of Louisville	KY	Kentucky	Southeast	Public
Old Dominion University	VA	Virginia	Southeast	Public
University of Miami	FL	Florida	Southeast	Private, not for-profit
Florida State University	FL	Florida	Southeast	Public
University of Florida	FL	Florida	Southeast	Public
University of Georgia	GA	Georgia	Southeast	Public
University of Kentucky	KY	Kentucky	Southeast	Public
Un. of North Carolina at Chapel Hill	NC	North Carolina	Southeast	Public
University of South Carolina	SC	South Carolina	Southeast	Public
University of Tennessee	TN	Tennessee	Southeast	Public
West Virginia University	WV	West Virginia	Southeast	Public
University of Alabama	AL	Alabama	Southeast	Public
University of South Florida	FL	Florida	Southeast	Public
Georgia State University	GA	Georgia	Southeast	Public

Mississippi State University	MS	Mississippi	Southeast	Public
University of Southern Mississippi	MS	Mississippi	Southeast	Public
University of Memphis	TN	Tennessee	Southeast	Public
Virginia Polytechnic Institute/State Un.	VA	Virginia	Southeast	Public
University of South Alabama	AL	Alabama	Southeast	Public
East Tennessee State University	TN	Tennessee	Southeast	Public
Middle Tennessee State University	TN	Tennessee	Southeast	Public
George Mason University	VA	Virginia	Southeast	Public
Florida Atlantic University	FL	Florida	Southeast	Public
East Carolina University	NC	North Carolina	Southeast	Public
Un. of N Carolina at Greensboro	NC	North Carolina	Southeast	Public
Jacksonville State University	AL	Alabama	Southeast	Public
University of North Alabama	AL	Alabama	Southeast	Public
Georgia Southern University	GA	Georgia	Southeast	Public
Eastern Kentucky University	KY	Kentucky	Southeast	Public
Morehead State University	KY	Kentucky	Southeast	Public
University of North Carolina at Wilmington	NC	North Carolina	Southeast	Public
Austin Peay State University	TN	Tennessee	Southeast	Public
James Madison University	VA	Virginia	Southeast	Public
Radford University	VA	Virginia	Southeast	Public
Murray State University	KY	Kentucky	Southeast	Public
Western Kentucky University	KY	Kentucky	Southeast	Public
Appalachian State University	NC	North Carolina	Southeast	Public
North Carolina Central University	NC	North Carolina	Southeast	Public
Un. of North Carolina at Charlotte	NC	North Carolina	Southeast	Public
Marshall University	WV	West Virginia	Southeast	Public
Texas Tech University	TX	Texas	Southwest	Public
Louisiana State University	LA	Louisiana	Southwest	Public
Oklahoma State University	OK	Oklahoma	Southwest	Public
University of Oklahoma	OK	Oklahoma	Southwest	Public
Texas A & M University	TX	Texas	Southwest	Public

University of Texas at Austin	TX	Texas	Southwest	Public
University of Arkansas	AR	Arkansas	Southwest	Public
New Mexico State University	NM	New Mexico	Southwest	Public
University of New Mexico	NM	New Mexico	Southwest	Public
University of North Texas	TX	Texas	Southwest	Public
University of New Orleans	LA	Louisiana	Southwest	Public
University of Texas at Dallas	TX	Texas	Southwest	Public
Texas A & M University	TX	Texas	Southwest	Public
East Central University	OK	Oklahoma	Southwest	Public
Southwest Texas State University	TX	Texas	Southwest	Public
Elmhurst College	IL	Illinois	West Lakes	Private, not for-profit
Carroll College	WI	Wisconsin	West Lakes	Private, not for-profit
Augustana College	IL	Illinois	West Lakes	Private, not for-profit
Macalister College	MN	Minnesota	West Lakes	Private, not for-profit
Northwestern University	IL	Illinois	West Lakes	Private, not for-profit
University of Chicago	IL	Illinois	West Lakes	Private, not for-profit
Southern Illinois Un. at Carbondale	IL	Illinois	West Lakes	Public
University of Illinois	IL	Illinois	West Lakes	Public
Indiana University at Bloomington	IN	Indiana	West Lakes	Public
The University of Iowa	IA	Iowa	West Lakes	Public
University of Minnesota at Minneapolis	MN	Minnesota	West Lakes	Public
University of Wisconsin at Madison	WI	Wisconsin	West Lakes	Public
University of Wisconsin at Milwaukee	WI	Wisconsin	West Lakes	Public
Northern Illinois University	IL	Illinois	West Lakes	Public
University of Illinois at Chicago	IL	Illinois	West Lakes	Public
University of Missouri at Columbia	MO	Missouri	West Lakes	Public
University of Wyoming	WY	Wyoming	West Lakes	Public
DePaul University	IL	Illinois	West Lakes	Private, not for-profit
University of St Thomas	MN	Minnesota	West Lakes	Private, not for-profit
Illinois State University	IL	Illinois	West Lakes	Public
Ball State University	IN	Indiana	West Lakes	Public
Indiana University at Indianapolis	IN	Indiana	West Lakes	Public

Indiana State University	IN	Indiana	West Lakes	Public
University of Missouri at Kansas City	MO	Missouri	West Lakes	Public
University of Wisconsin at Platteville	WI	Wisconsin	West Lakes	Public
University of Wisconsin at Whitewater	WI	Wisconsin	West Lakes	Public
Eastern Illinois University	IL	Illinois	West Lakes	Public
University of Minnesota at Duluth	MN	Minnesota	West Lakes	Public
Northwest Missouri State University	MO	Missouri	West Lakes	Public
University of Wisconsin at Eau Claire	WI	Wisconsin	West Lakes	Public
University of Wisconsin at River Falls	WI	Wisconsin	West Lakes	Public
University of Wisconsin at La Crosse	WI	Wisconsin	West Lakes	Public
University of Wisconsin at Oshkosh	WI	Wisconsin	West Lakes	Public
Un. of Wisconsin at Stevens Point	WI	Wisconsin	West Lakes	Public
Valparaiso University	IN	Indiana	West Lakes	Private, not for-profit
Chicago State University	IL	Illinois	West Lakes	Public
Northeastern Illinois University	IL	Illinois	West Lakes	Public
Southern Illinois Un. at Edwardsville	IL	Illinois	West Lakes	Public
Western Illinois University	IL	Illinois	West Lakes	Public
University of Northern Iowa	IA	Iowa	West Lakes	Public
Minnesota State University	MN	Minnesota	West Lakes	Public
St Cloud State University	MN	Minnesota	West Lakes	Public
Southwest Missouri State University	MO	Missouri	West Lakes	Public
Bemidji State University	MN	Minnesota	West Lakes	Public

Bach/Mas/Doc	Carnegie Code	Carnegie Classification (2000)
B	BL	Baccalaureate Colleges—Liberal Arts
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive
B	DI	Doctoral/Research Universities—Intensive
B	DI	Doctoral/Research Universities—Intensive
B	DI	Doctoral/Research Universities—Intensive
M	DI	Doctoral/Research Universities—Intensive
M	DI	Doctoral/Research Universities—Intensive
B	M-I	Master's Colleges and Universities I
B	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
B	BG	Baccalaureate Colleges—General
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive
B	DI	Doctoral/Research Universities—Intensive
M	DI	Doctoral/Research Universities—Intensive
M	DI	Doctoral/Research Universities—Intensive
M	DI	Doctoral/Research Universities—Intensive
M	DI	Doctoral/Research Universities—Intensive
B	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
B	M-II	Master's Colleges and Universities II
B	SO	Specialized Institutions—Other specialized institutions
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive
B	DI	Doctoral/Research Universities—Intensive
B	M-I	Master's Colleges and Universities I
B	M-I	Master's Colleges and Universities I

B	M-I	Master's Colleges and Universities I
D	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
B	BG	Baccalaureate Colleges—General
B	BL	Baccalaureate Colleges—Liberal Arts
B	BL	Baccalaureate Colleges—Liberal Arts
B	BL	Baccalaureate Colleges—Liberal Arts
B	BL	Baccalaureate Colleges—Liberal Arts
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive
B	DI	Doctoral/Research Universities—Intensive
M	DI	Doctoral/Research Universities—Intensive
B	M-I	Master's Colleges and Universities I
B	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
B	M-I	Master's Colleges and Universities I
B	M-I	Master's Colleges and Universities I
B	M-I	Master's Colleges and Universities I
B	M-I	Master's Colleges and Universities I
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B	M-I	Master's Colleges and Universities I
B	M-I	Master's Colleges and Universities I
B	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
B	SO	Specialized Institutions—Other specialized institutions
B	BG	Baccalaureate Colleges—General
B	BL	Baccalaureate Colleges—Liberal Arts
B	BL	Baccalaureate Colleges—Liberal Arts
B	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive
B	DI	Doctoral/Research Universities—Intensive
D	DI	Doctoral/Research Universities—Intensive
B	M-I	Master's Colleges and Universities I
B	M-I	Master's Colleges and Universities I

B	M-I	Master's Colleges and Universities I
B	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
B	M-II	Master's Colleges and Universities II
B	AC	Associate Colleges
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
B	DI	Doctoral/Research Universities—Intensive
D	DI	Doctoral/Research Universities—Intensive
M	DI	Doctoral/Research Universities—Intensive
D	D-I	Doctoral/Research Universities-Intensive
B	M-I	Master's Colleges and Universities I
B	M-I	Master's Colleges and Universities I
B	M-I	Master's Colleges and Universities I
B	M-I	Master's Colleges and Universities I
B	M-I	Master's Colleges and Universities I
B	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
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M	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
B	BG	Baccalaureate Colleges—General
B	BL	Baccalaureate Colleges—Liberal Arts
B	BL	Baccalaureate Colleges—Liberal Arts
B	DE	Doctoral/Research Universities—Extensive
B	DE	Doctoral/Research Universities—Extensive

B	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive
B	DI	Doctoral/Research Universities—Intensive
B	DI	Doctoral/Research Universities—Intensive
B	DI	Doctoral/Research Universities—Intensive
D	DI	Doctoral/Research Universities—Intensive
M	DI	Doctoral/Research Universities—Intensive
M	DI	Doctoral/Research Universities—Intensive
M	DI	Doctoral/Research Universities—Intensive
B	M-I	Master's Colleges and Universities I
B	M-I	Master's Colleges and Universities I
B	M-I	Master's Colleges and Universities I
B	M-I	Master's Colleges and Universities I
B	M-I	Master's Colleges and Universities I
B	M-I	Master's Colleges and Universities I
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M	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
B	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive

M	DE	Doctoral/Research Universities—Extensive
B	DI	Doctoral/Research Universities—Intensive
D	DI	Doctoral/Research Universities—Intensive
M	DI	Doctoral/Research Universities—Intensive
B	M-I	Master's Colleges and Universities I
D	M-I	Master's Colleges and Universities I
B	BG	Baccalaureate College General
B	BG	Baccalaureate Colleges—General
B	BL	Baccalaureate Colleges—Liberal Arts
B	BL	Baccalaureate Colleges—Liberal Arts
B	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
D	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive
M	DE	Doctoral/Research Universities—Extensive
B	DI	Doctoral/Research Universities—Intensive
B	DI	Doctoral/Research Universities—Intensive
B	DI	Doctoral/Research Universities—Intensive
B	DI	Doctoral/Research Universities—Intensive
B	DI	Doctoral/Research Universities—Intensive
D	DI	Doctoral/Research Universities—Intensive
D	DI	Doctoral/Research Universities—Intensive
B	M-I	Master's Colleges and Universities I
B	M-I	Master's Colleges and Universities I
B	M-I	Master's Colleges and Universities I
B	M-I	Master's Colleges and Universities I
B	M-I	Master's Colleges and Universities I
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B	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I
M	M-I	Master's Colleges and Universities I

M	M-I	Master's Colleges and Universities I
B	M-II	Master's Colleges and Universities II

APPENDIX D

Survey Questionnaire Respond Table

Name of the Institution	Q6	Q7	Q8	Q9	Q10	Q11a	Q11b	Q11c	Q11d	Q11e	Q11f	Q12	Q13
University of Denver	3	3	2	3	2	1	1	0	0	1	0	1	1
The George Washington University	3	3	2	2	1	1	0	0	0	0	0	2	1
University of Miami	1	1	1	2	2	1	0	0	0	0	0	2	2
Elmhurst College	1	3	1	1	2	1	0	0	0	0	0	2	1
Augustana College	1	3	1	1	2	1	0	0	0	0	0	2	2
University of St. Thomas	1	3	3	2	1	1	0	0	0	0	0	2	1
Vassar College	1	3	1	1	2	1	0	0	0	0	0	2	2
Ohio Wesleyan University	1	3	1	1	2	1	0	0	0	0	0	2	2
Auburn University	1	3	1	1	3	1	0	0	0	0	0	2	1
University of S Alabama	1	3	1	1	2	1	0	0	0	0	0	2	1
University of Arkansas	3	2	3	1	2	1	1	0	0	0	0	2	2
University of Arizona	3	3	4	2	1	1	0	0	0	0	0	2	0
Sonoma State Univ.	1	3	1	1	2	1	0	0	0	0	0	2	1
Humboldt State University,	3	2	4	3	0	0	1	0	1	1	0	2	2
University of California, Santa Barbara	3	3	4	2	2	0	0	0	0	0	1	1	2
San Diego State	3	3	2	3	1	0	1	0	0	0	0	2	1
San Francisco State University	0	0	2	4	0	1	1	0	0	0	0	2	1
California State University San Bernardino	1	3	1	1	2	1	0	0	0	0	0	2	1
California State University, Chico	1	3	2	3	2	1	0	1	0	0	0	2	2
California State University, Long Beach	3	3	2	4	3	1	1	0	0	0	0	2	1
College of	0	0	0	0	0	0	0	0	0	0	0	0	0

Alameda													
University of Colorado at Colorado Springs	3	3	2	1	2	1	1	0	0	0	0	2	1
University of Connecticut, Department of Geography	3	3	1	2	1	1	1	0	0	0	0	2	2
Department of Geography, University of Florida	3	2	2	1	2	1	1	0	0	0	0	2	2
Florida State University	3	3	2	1	2	1	0	0	0	0	0	2	1
Florida Atlantic University	3	3	4	4	1	0	1	0	1	0	0	2	1
Georgia S University	1	3	1	2	1	1	0	0	0	0	0	2	2
Georgia State University	3	3	2	2	2	1	1	0	0	0	0	2	1
University of Iowa	3	3	3	2	2	1	0	0	0	0	0	2	2
University of Northern Iowa	3	3	1	1	2	0	1	0	1	1	0	2	2
Illinois State University	1	3	1	1	1	1	0	0	0	0	0	2	1
Ball State University	3	3	2	2	2	1	0	0	0	0	0	2	2
Eastern Kentucky University	1	3	1	1	2	1	0	0	0	0	0	2	2
University of Louisville	3	3	2	1	1	1	0	0	0	0	0	2	1
Murray State University	3	3	2	2	2	0	0	0	1	1	0	2	2
Western Kentucky University	3	3	1	1	2	0	1	0	0	0	0	2	1
Bridgewater State College	1	3	1	1	2	1	0	0	0	0	0	2	1
University of Massachusetts Boston	3	3	3	4	1	0	1	0	0	0	0	2	1
Salisbury University	1	3	2	2	2	1	0	0	0	0	0	2	2
University of Maryland, College Park	3	3	3	2	1	0	0	0	1	0	0	2	1

Northern Michigan University	1	3	1	1	2	1	1	1	0	0	0	2	2
Michigan State University	3	3	4	4	2	1	1	0	0	1	0	2	1
Western Michigan University	3	3	3	1	2	1	0	0	0	0	0	2	2
Central Michigan University	0	2	4	4	2	0	0	0	1	0	0	2	2
Bemidji State University	3	2	1	1	2	0	0	0	1	0	0	2	1
University of Missouri-Kansas City	1	3	1	1	2	1	0	0	0	0	0	2	1
Univ of Missouri--Columbia	0	0	1	3	2	1	1	0	0	0	0	2	2
Montana State University, Bozeman, Montana	3	3	2	1	2	1	0	1	0	0	0	2	1
The University of Montana	0	0	0	0	0	0	0	0	0	0	0	0	0
UNC Wilmington	3	2	1	2	2	1	0	0	0	0	0	2	1
University of North Carolina at Chapel Hill	3	3	2	2	2	1	0	0	0	0	0	0	2
Univ. North Carolina Greensboro	3	3	2	3	2	1	1	0	0	0	0	2	2
Appalachian State University	3	2	1	1	2	0	0	0	1	1	0	2	2
North Carolina Central University	3	2	1	1	3	1	0	0	0	0	0	2	1
Un. Of North Carolina at Charlotte	3	3	4	3	2	1	0	0	0	0	0	2	2
University of North Dakota	3	3	2	1	2	0	1	0	0	0	0	2	2
Univ. of Nebraska at Kearney	1	3	1	1	2	1	0	0	0	0	0	2	2
University of Nebraska	3	3	2	1	2	1	1	0	0	0	0	2	2
University of Nebraska - Omaha	3	0	1	2	2	1	1	0	0	0	0	2	2
University of New Hampshire	1	2	1	2	2	1	0	0	0	0	0	2	2

Rowan University	1	3	1	2	1	1	1	0	1	0	0	2	1
State University of New York at New Paltz	1	3	1	1	3	1	0	0	0	0	0	2	1
State University of New York College at Geneseo	1	3	1	1	2	1	0	0	0	0	0	2	2
Department of Geography	3	3	3	4	1	0	0	0	1	0	0	2	2
State University of NY at Albany	3	3	4	3	1	1	1	0	0	0	0	2	1
Youngstown State University	1	3	1	1	2	1	0	0	0	0	0	2	1
Bowling Green State University	3	3	1	1	2	1	0	0	0	0	0	2	2
Kent State University	3	3	2	1	2	1	0	0	0	0	0	2	1
Ohio University	3	3	4	3	2	0	0	0	1	0	0	2	2
Miami University	3	3	1	2	2	1	0	0	0	0	0	2	0
University of Akron	3	3	1	1	1	1	0	0	0	0	0	2	1
Oklahoma State University	3	3	4	4	1	1	1	0	0	0	0	2	2
Oregon State University - Geosciences Department	3	2	4	3	2	1	0	0	0	0	0	1	2
Portland State University	3	3	3	3	1	1	0	0	0	0	0	2	1
Kutztown University	1	3	1	1	2	1	0	0	0	0	0	2	2
Mansfield University	1	3	1	1	2	1	0	0	0	0	0	2	2
University of Pittsburgh	3	2	1	2	2	1	1	0	0	1	0	2	1
California University of Pennsylvania	3	3	3	2	2	1	1	0	1	0	0	1	1
Shippensburg University of PA	3	3	1	3	1	0	1	0	1	0	0	2	2
West Chester University	3	3	4	4	2	1	0	0	0	0	0	2	1
South Dakota State University	3	3	2	3	2	0	0	0	1	0	0	2	2
Austin Peay State	1	2	1	1	2	1	0	0	0	0	0	2	1

University													
East Tennessee State University	3	3	1	1	2	1	0	0	0	0	0	2	1
University of Tennessee	3	3	2	2	1	0	0	0	1	1	1	2	2
University of Memphis	3	3	1	2	1	1	0	0	0	0	0	2	1
Texas Tech University	3	3	2	1	2	1	0	0	0	0	0	2	2
University of Texas at Austin	3	2	3	2	2	1	0	0	0	0	0	2	1
Utah state university	3	3	2	2	1	1	0	0	1	1	0	1	2
Dept. of Geography, Univ. of Wisconsin-La Crosse	3	3	2	3	1	1	0	0	0	0	0	2	2
University of Wisconsin Oshkosh	3	3	1	1	1	1	0	0	1	0	0	2	1
Univ of Wisconsin	3	3	3	3	2	1	1	0	1	1	0	2	0
None	1	3	1	1	3	1	0	0	0	0	0	2	2
None	3	3	1	2	2	1	0	0	0	0	0	2	2

APPENDIX E

Questionnaire Responses and their Distribution according to Carnegie Classification of Institutions

	Regional Divisions									
Q1	P Cost	Great Pl	SW	W Lakes	SE	Mid Atlan	Mid States	E Lakes	New Eng	N/A
Yes	11	9	4	12	22	3	12	10	3	2
No	1	1		1				1	1	
	Regional Divisions									
Q2	P	Great Pl	SW	W Lakes	SE	Mid Atlan	Mid States	E Lakes	New Eng	N/A
Undergraduate	3	1	0	5	6	1	6	3	2	2
Graduate	0	0	0	0	0	0	0	0	0	0
Both	9	9	4	8	16	2	6	8	2	0
	Regional Divisions									
Q3	Pacific Cost	Great Pl	SW	W Lakes	SE	Mid Atlan	Mid States	E Lakes	New Eng	N/A
Socioeconomic Applications	2	1	0	0	1	0	0	0	0	0
Environmental Applications	2	0	2	1	5	0	1	1	1	0
Both	8	9	2	12	16	0	13	10	3	2
	Regional Divisions									
Q4	Pacific Cost	Great Pl	SW	W Lakes	SE	Mid Atlan	Mid States	E Lakes	New Eng	N/A
0-50	3	3	0	8	12	0	8	5	3	0

51-100	4	7	1	2	8	2	0	1	0	0
101-150	1	0	2	3	0	1	2	1	1	0
More than 150	4	0	1	0	4	0	2	3	0	0
	Regional Divisions									
Q5	Pacific Cost	Great Pl	SW	W Lakes	SE	Mid Atlan	Mid States	E Lakes	New Eng	N/A
1-3	2	5	2	6	11	0	5	7	1	
4-6	2	2	1	3	8	3	3	1	2	
7-9	5	2	0	3	2	0	2	1	0	
More than 9	2	0	1	0	1	0	2	2	1	
	Regional Divisions									
Q6	Pacific Cost	Great Pl	SW	W Lakes	SE	Mid Atlan	Mid States	E Lakes	New Eng	N/A
Large Increase	3	1	1	4	5	2	4	1	2	0
Small Increase	5	2	3	9	15	1	7	10	0	0
No change	1	0	0	0	2	0	1	0	0	1
	Regional Divisions									
Q7	Pacific Cost	Great Pl	SW	W Lakes	SE	Mid Atlan	Mid States	E Lakes	New Eng	N/A
Academic theory and application GIS courses only	8	7	4	11	17	2	10	9	3	0
Certificate Program	4	5	2	3	5	0	5	2	2	0
Certification Program	1	1	0	0	0	0	0	1	0	0
Bachelor in GIS	1	2	0	4	4	1	4	2	0	0
Masters in GIS	1	2	0	2	3	0	1	1	0	0

Ph.D. in GIS	1	0	0	0	1	0	0	0	0	0
	Regional Divisions									
Q8	Pacific Cost	Great Pl	SW	W Lakes	SE	Mid Atlan	Mid States	E Lakes	New Eng	N/A
Yes	2	2	0	0	0	0	1	0	0	0
No	9	7	4	13	21	3	11	11	4	0
	Regional Divisions									
Q9	Pacific Cost	Great Pl	SW	W Lakes	SE	Mid Atlan	Mid States	E Lakes	New Eng	N/A
Local market (within 50 miles)	6	3	1	6	12	2	6	4	2	0
Outside the local market	4	6	3	6	10	1	6	6	2	0

	Control		Carnegie Code							Degree offered		
Q1	Public	Private	DE	DI	AC	BG	BL	M-I	M-II	Bach	Mas	Doc
Yes	78	10	29	16	0	2	3	35	1	34	32	20
No	5		2	2	1	0	0	0	0	2	1	2

	Control		Carnegie Code							Degree offered		
Q2	Public	Private	DE	DI	AC	BG	BL	M-I	M-II	Bach	Mas	Doc
Undergraduate	21	6	3	4	0	1	3	16	0	22	3	2
Graduate	0	0	0	0	0	0	0	0	0	0	0	0
Both	61	2	28	14	1	1	0	19	1	14	31	19

	Control		Carnegie Code							Degree offered		
Q3	Public	Private	DE	DI	AC	BG	BL	M-I	M-II	Bach	Mas	Doc
Socioeconomic Applications	3	1	1	0	1	0	0	2	0	1	2	1
Environmental Applications	13	0	5	1	1	0	0	1	0	7	3	3
Both	69	7	25	16	0	1	3	27	1	28	29	17

	Control		Carnegie Code							Degree offered		
Q4	Public	Private	DE	DI	AC	BG	BL	M-I	M-II	Bach	Mas	Doc
0-50	37	5	6	8	1	2	3	22	1	27	14	2
51-100	23	2	12	6	0	0	0	7	0	5	12	8
101-150	10	1	6	2	0	0	0	3	0	2	3	6
More than 150	12	0	7	2	0	0	0	3	0	2	5	5

	Control		Carnegie Code							Degree offered		
Q5	Public	Private	DE	DI	AC	BG	BL	M-I	M-II	Bach	Mas	Doc
1-3	26	4	9	7	0	1	3	18	0	23	12	5
4-6	22	3	13	3	0	1	0	8	0	8	9	8
7-9	14	1	6	4	0	0	0	5	0	2	8	5
More than 9	10	0	3	2	0	0	0	4	0	2	4	3

	Control		Carnegie Code							Degree offered		
Q6	Public	Private	DE	DI	AC	BG	BL	M-I	M-II	Bach	Mas	Doc
Large Increase	21	2	10	6	0	0	0	7	0	8	8	7
Small Increase	54	6	20	11	0	2	3	23	1	24	22	14
No change	4	0	1		0	0	0	3	0	2	2	0

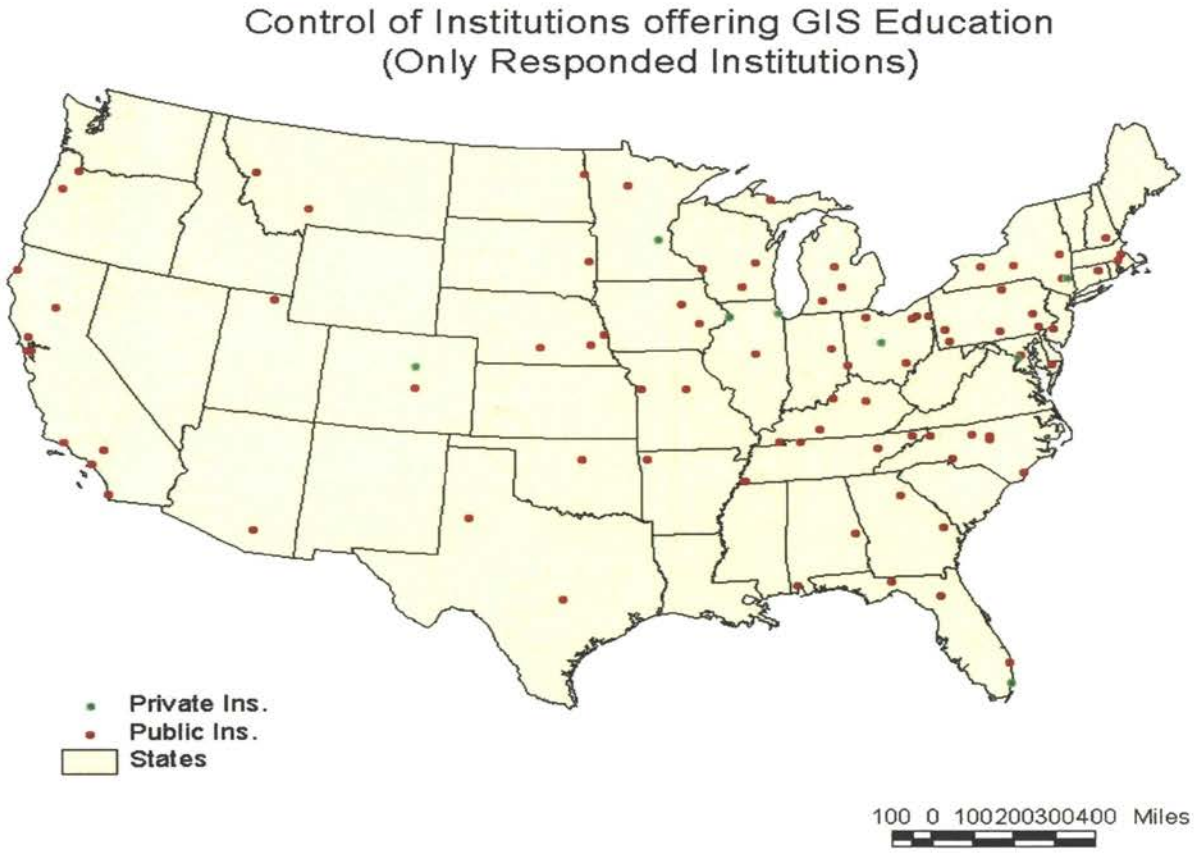
	Control		Carnegie Code							Degree offered		
Q7	Public	Private	DE	DI	AC	BG	BL	M-I	M-II	Bach	Mas	Doc
Academic theory and application GIS courses only	63	8	27	12	0	2	3	27	0	31	24	16
Certificate Program	27	1	12	4	0	1		11	0	4	16	8
Certification Program	3	0	0	1	0	0	0	2	0	1	2	0
Bachelor in GIS	18	0	4	3	0	0	0	10	1	6	9	3
Masters in GIS	10	1	5	0	0	1	0	4	0	2	4	4
Ph.D. in GIS	2	0	2	0	0	0	0	0	0	0	0	2

	Control		Carnegie Code							Degree offered		
Q8	Public	Private	DE	DI	AC	BG	BL	M-I	M-II	Bach	Mas	Doc
Yes	4	1	4	0	0	0	0	1	0	0	2	3
No	78	7	27	17	0	2	3	34	1	35	31	17

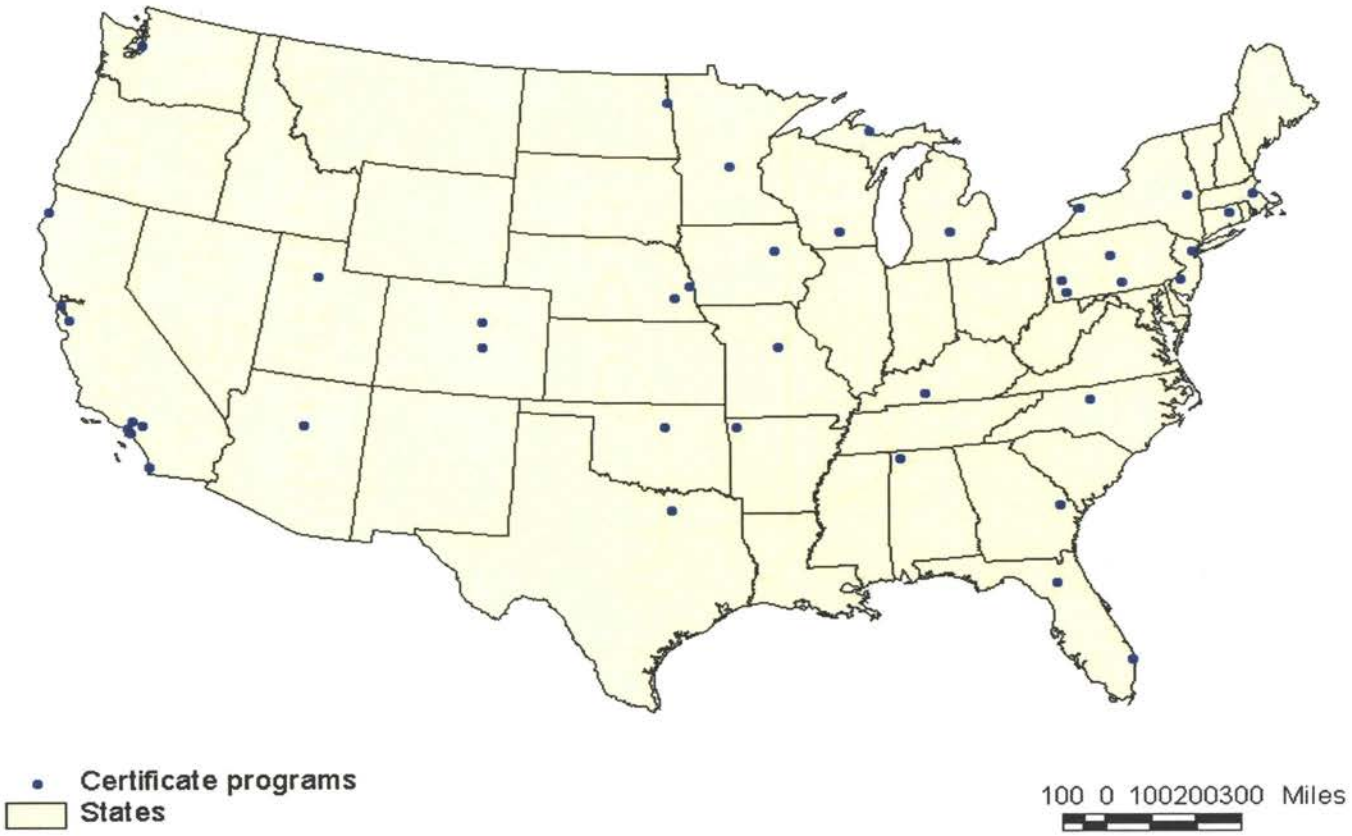
	Control		Carnegie Code							Degree offered		
Q9	Public	Private	DE	DI	AC	BG	BL	M-I	M-II	Bach	Mas	Doc
Local market (within 50 miles)	38	4	12	10	0	2	0	17	1	16	16	10
Outside the local market	44	4	17	6	0	0	3	18	0	19	16	9

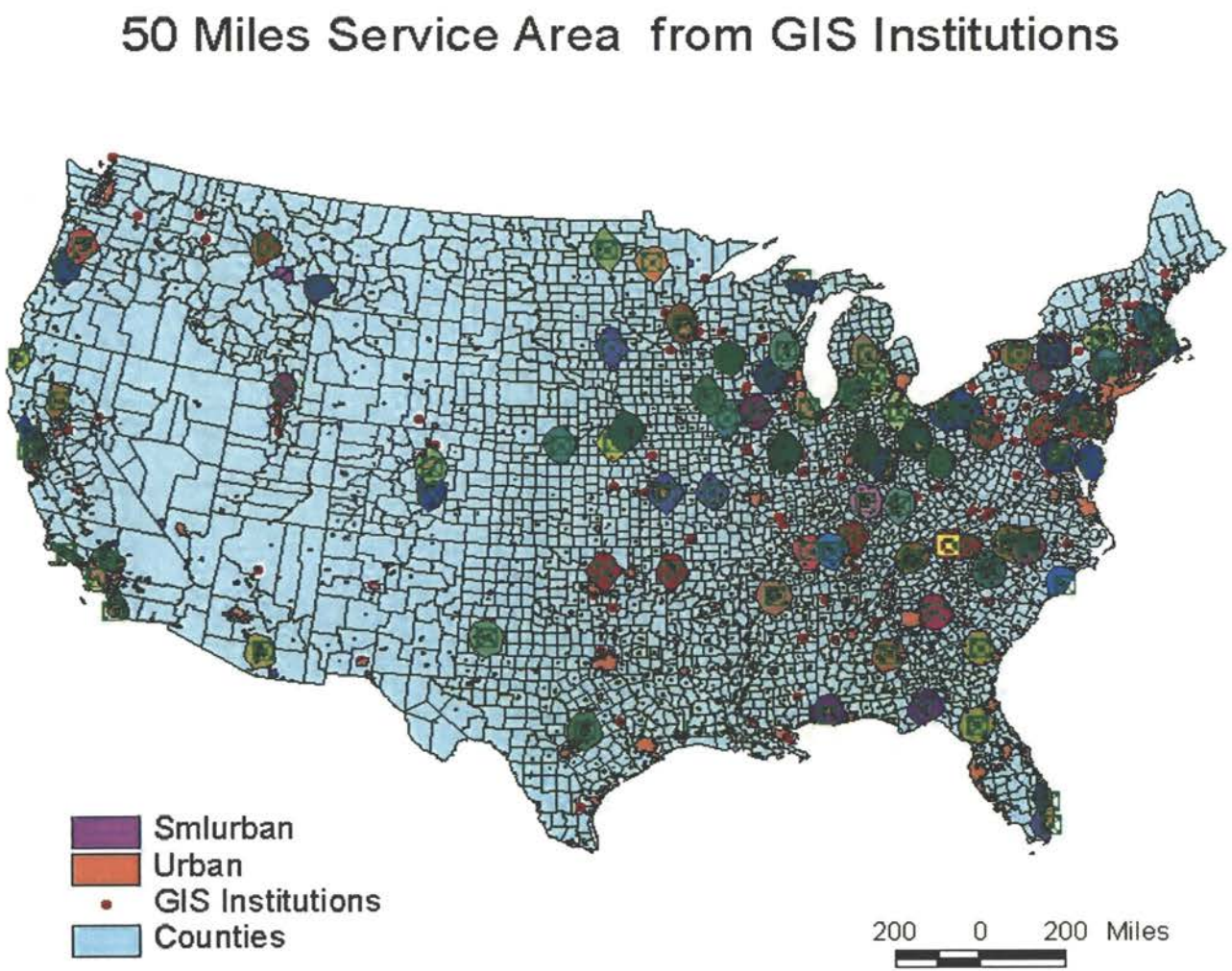
APPENDIX F

MAPS



Institutions offering GIS Ceritificate Programs




50 Miles Service Area from GIS Institutions
Smlurban
Urban
GIS Institutions
Counties
200 0 200 Miles

APPENDIX G

The County Population* within 50-Mile Zone from GIS Institutions.

Institutions	Population (2000)
Auburn University	968,428
University of South Alabama	1,082,935
University of Arkansas	574,890
University of Arizona	1,179,609
Sonoma State University	4,480,279
Humboldt State University	167,047
California at Santa Barbara	1,152,544
San Diego State University	4,359,220
S Francisco St. Multidisciplinary GIS Center	7,039,362
California State at S. Bernardino	13,435,804
California State University at Chico	464,440
California State at Long Beach	19,187,478
College of Alameda	7,602,960
University of Denver	3,418,958
Colorado at Colorado Spring	1,471,908
University of Connecticut	4,866,213
George Washington University	7,147,175
University of Miami	3,085,168
University of Florida	1,865,617
Florida State University	622,583
Florida Atlantic University	3,073,628
Georgia Southern University	625,769
Georgia State University	2,439,167
The University of Iowa	980,397
University of Northern Iowa	618,868
Illinois State University	1,161,665
Elmhurst College	9,083,137
Augustan a College	873,040
Ball State University	2,073,989
Eastern Kentucky University	939,381
University of Louisville	1,590,674
Murray State University	569,270
Western Kentucky University	1,324,778
Bridgewater State College	6,926,121
University of Massachusetts-Boston	7,216,142
Salisbury State University	571,832
University of Maryland College Park	7,253,961

Northern Michigan University	162,372
Michigan State University	3,029,649
Western Michigan State University	2,178,834
Central Michigan University	1,503,237
University of St Thomas	3,417,845
Bemidji State University	232,218
University of Missouri at Kansas City	2,092,968
University of Missouri at Columbia	504,583
Montana State University	110,351
University of Montana	206,941
North Carolina at Wilmington	621,138
North Carolina at Chapel Hill	2,529,308
North Carolina at Greensboro	2,183,316
Appalachian State University	999,899
North Carolina Central University	2,327,581
North Carolina at Charlotte	2,399,984
University of North Dakota	296,805
University of Nebraska at Kearney	213,151
University of Nebraska at Lincoln	1,057,786
University of Nebraska at Omaha	1,141,920
University of New Hampshire	5,669,310
Rowan University	8,835,082
Vassar College	5,687,366
State University of New York at New Paltz	5,367,729
State University of New York College at Geneseo	2,349,119
State University of New York College at Cortland	1,758,807
State University of New York at Albany	1,863,191
Ohio Wesleyan University	2,314,913
Youngstown State University	5,821,238
Bowling Green State University	3,885,644
Kent State University	4,659,174
Ohio University	791,695
Miami University	3,065,168
University of Akron	4,241,455
Oklahoma State University	1,683,103
Oregon State University	980,866
Portland State University	2,531,004
Kutztown University of Pennsylvania	492,084
Mansfield University of Pennsylvania	509,618
University of Pittsburgh at Johnstown	3,402,649
California University of Pennsylvania	2,785,427
Shippensburg University of Pennsylvania	1,805,233

West Chester University	8,128,041
South Dakota State University	356,598
Austin Peay State University	1,490,077
East Tennessee State University	1,105,334
University of Tennessee	1,160,912
University of Memphis	1,510,396
Texas Tech University	375,125
University of Texas at Austin	1,772,913
Utah State University	676,183
University of Wisconsin at La Crosse	419,576
University of Wisconsin at Oshkosh	1,351,498
University of Wisconsin at Madison	1,491,040

* The population statistics is county level and gathered from Census 2000.

Oklahoma State University Institutional Review Board

Protocol Expires: 6/3/2002

Date: June 04, 2001 IRB Application AS0130

Proposal Title: CURRENT STATUS OF GIS (GEOGRAPHIC IINFORMATION SYSTEM) IN THE US EDUCATION SYSTEM

Principal Investigator(s):

Halil Tas
225 Scott Hall
Stillwater, OK 74078

Allen Finchum
219 Sc Hall
Stillwater, OK 74078

Reviewed and Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved

Dear PI :

Your IRB application referenced above has been approved for one calendar year. Please make note of the expiration date indicated above. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved projects are subject to monitoring by the IRB. If you have questions about the IRB procedures or need any assistance from the Board, please contact Sharon Bacher, the Executive Secretary to the IRB, in 415 Whitehurst (phone: 405-744-5700, sbacher@okstate.edu).

Sincerely,

Carol Olson, Chair
Institutional Review Board

VITA #2

Halil Ibrahim Tas

Candidate for the Degree of

Doctor of Education

Dissertation: STATUS OF GIS EDUCATION AT 4-YEAR COLLEGES AND UNIVERSITIES IN THE UNITED STATES

Major Field: Geography

Biographical:

Personal Data: Born in Silifke, Mersin - Turkey, on January 01, 1971.

Education: Attended public school (Elementary, Middle, and Higher School) in Silifke, Turkey and graduated from Silifke Lisesi in June 1987. Following high school, he attended Black Sea Technical University in Trabzon, Turkey and in June of 1991 received the Bachelor of Science degree with a major in Geography Teaching. Received the Master of Science degree with a major in Geography in 1998. Completed the requirements for the degree of Doctor of Education at Oklahoma State University in May 2003.

Experience: Upon completion of the Bachelor's degree, he started to teach geography in Gokcebey Lisesi, Zonguldak, Turkey in September, 1991. After working three years, he was named one of two geography teachers sent abroad for graduate studies. He attended intensive English courses from June 1994 to December 1994 in Middle East Technical University and at the University of Arkansas, USA from February 1995 to December, 1995. Upon completion of the language study, he entered the graduate program in geography at Oklahoma State University, Stillwater, Oklahoma, from which he received the Master of Arts degree in geography in December 1997. In January, 1998,

he began a doctoral program at the same university.

Professional Memberships: Association of American Geographers, National Consul for Geographic Education, and National Geographic Society.

He is presently employed as a research assistant at Oklahoma State University, Department of Geography/Cartography Services. He lives in Stillwater, Oklahoma, and is married with one son, Alperen, and daughter, Betul Sena.